Wood Furniture Industries

Notice

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Users are encouraged to duplicate portions of this publication or in its entirety as needed to implement a waste reduction program.

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Introduction

This Workbook is provided to you as a tool to help keep your company

COMPETITIVE !!!

The Wood Furniture Industry Waste Reduction Opportunities Workbook provides a compilation of waste reduction ideas that can reduce costs and improve customer satisfaction and company image. It will also prevent the pollution of our environment, and in many cases maintain a safe workplace.

- Reduce Costs By
  - conserving raw materials
  - minimizing waste volume and toxicity
  - eliminating or minimizing the number of regulatory requirements
  - that apply to your operations and the risk of associated penalties

- Improve Customer Satisfaction / Company Image By
  - meeting the customer's growing desire for environmentally-responsible products made by environmentally-responsible processes
  - being recognized as a good corporate neighbor who protects the environment
  - providing workers a safer workplace with less hazardous materials and processes

This Workbook complements -

- the American Furniture Manufacturers Association (AFMA) Environmental Guide for the Furniture Industry which provides information for regulatory compliance and environmental management. (see Chapter 5 of the AFMA document which specifically addresses pollution prevention and waste reduction), and

- EPA's Facility Pollution Prevention Guide (EPA/600/R92/088, May 1992) which provides information for establishing and implementing a pollution prevention/waste reduction program at your facility.

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About the Workbook

Wood Furniture Industry Waste Reduction Opportunities was developed by the Tennessee Valley Authority (TVA) with a grant from the US Environmental Protection Agency (EPA), Center for Environmental Research Information (CERI).

Purpose

The purpose of this Workbook is to provide a simple, easy to use reference of waste reduction opportunities for the Wood Household Furniture Industry, with a primary focus on SIC 2511, Wood Household Furniture. Use the Workbook to help identify waste reduction opportunities that you can apply at your facility.

Design of the Workbook

For users just starting waste reduction programs, a brief overview of the basic steps for developing a waste reduction program, as recommended by EPA is provided.

Waste reduction opportunities and practices are provided in a summary format for each of the respective major manufacturing processes typically found in the wood household furniture industry. For each process, there is a brief process description, a table that lists the respective waste reduction opportunities for that process, followed by summaries of each waste reduction opportunity.

The information provided in the waste reduction opportunity summaries includes -

- a description of the opportunity and its benefits,
- the references used to obtain information for this Workbook and where additional information can be found,

and as available -

- any "watch-outs" regarding implementation,
- brief case studies of the successful application of the opportunity, and cost information.

The degree of benefit that results from implementing any of the waste reduction opportunities is highly dependent upon the operations at your facility. For example, large manufacturers with large lumber inventories and kiln drying facilities may realize a significant benefit from implementing the opportunities summarized in Section 1 - Lumber Receiving, Drying and Storage. However, smaller manufacturers may find their largest benefits in Section 4 - Finishing, as finishing operations may generate the majority of wastes in a smaller manufacturing facility.

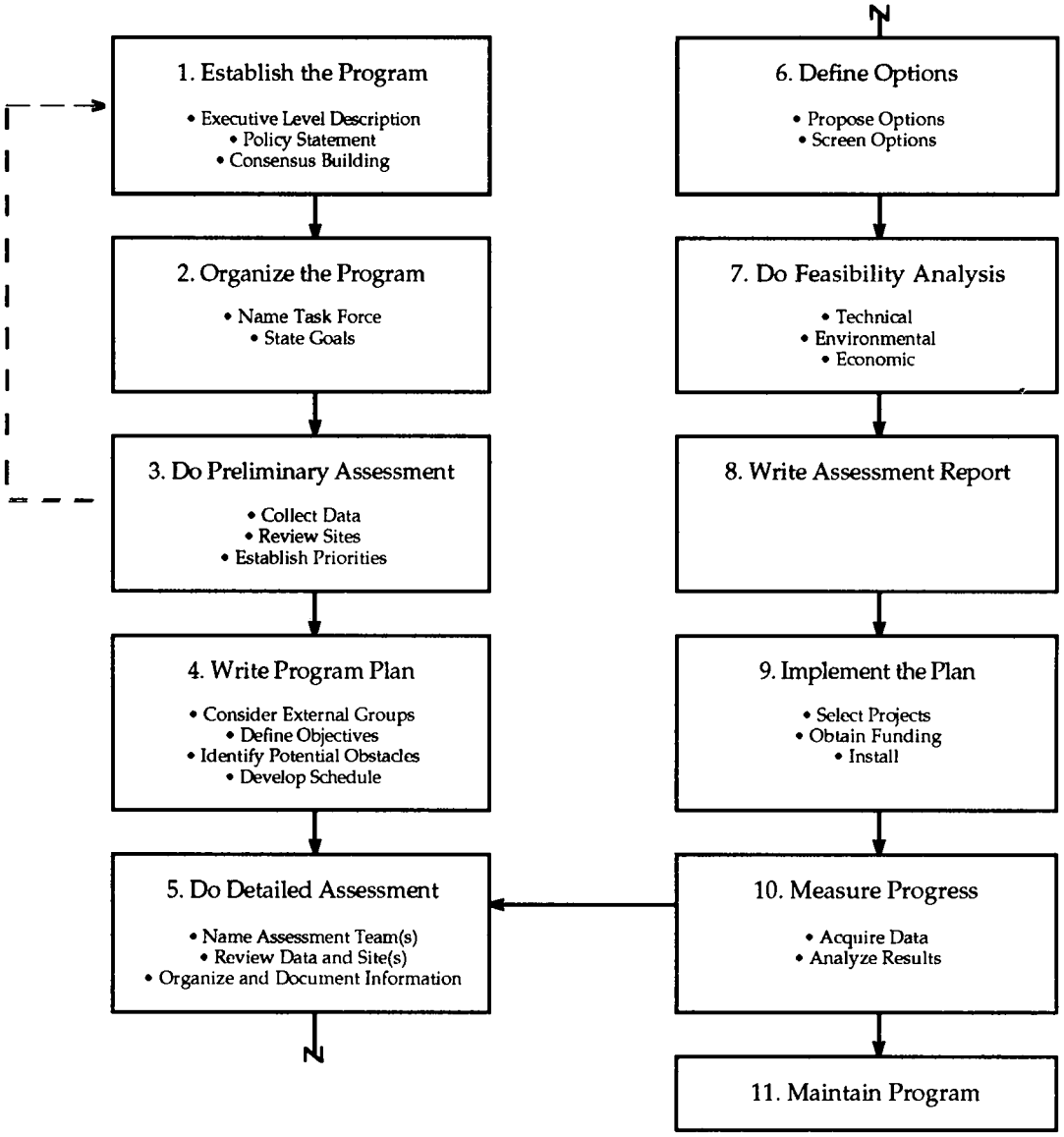
Also, government regulations are becoming more stringent for solvents and other coating chemical wastes, and the cost of pollution controls and hazardous waste disposal is increasing. Therefore focusing your waste reduction efforts in finishing operations is likely to provide more significant benefits.

Additional information contained in the Workbook includes sections containing:

- a compilation of Waste Reduction Resources that can provide assistance such as Federal and State programs, waste exchanges, and vendors
- a listing of the References used in preparing this document, and
- an Index to help you find information in the workbook.

Steps for Developing A Waste Reduction Program

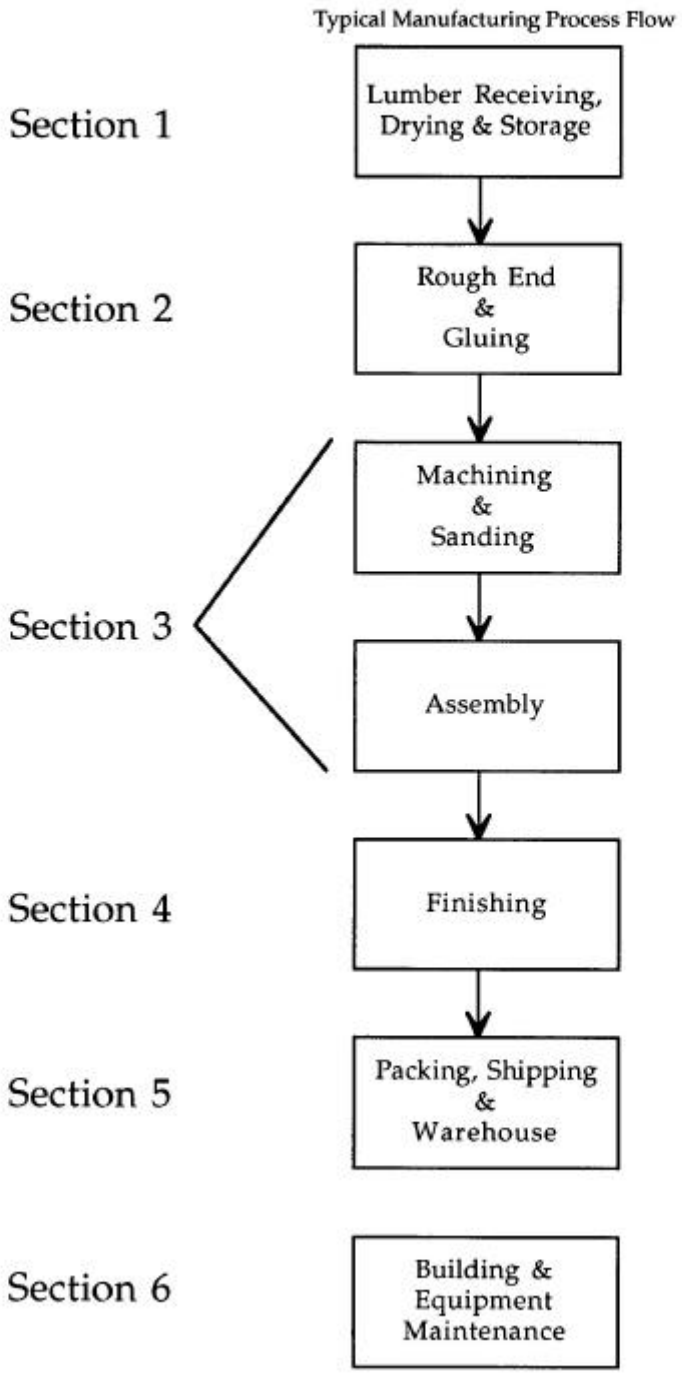
The following are the steps recommended by EPA.



Some key factors for success include visible commitment from facility leadership, program ownership and support by all employees, multi-functional participation, establishment of waste reduction goals, management systems for tracking the types and amounts of materials, wastes and associated costs, and the measurement and celebration of progress.

Additional information on developing a program can be found in the EPA Facility Pollution Prevention Guide, Document Number EPA/600/R-92/088, May 1992.

Waste Reduction Opportunities



1 Lumber Receiving, Drying and Storage

Process Description

The typical functions of lumber receiving, drying and storage include:

- unloading
- grading
- sorting
- stacking
- air-drying
- kiln drying
- dry shed storage
- maintaining inventory records.

The purpose of this process is to receive, prepare and maintain an adequate inventory of appropriate quality lumber for the subsequent manufacturing processes.

Lumber Receiving, Drying and Storing Wastes

- wood
- energy
- air emissions from boiler
- condensate from dehumidification

Opportunity Summary

The following are opportunities for waste reduction in Lumber Receiving and Storage. Summaries of these opportunities follow.

1. Arrange Lumber Delivery to Minimize Inventory and Storage Time
2. Inspect and Sort Lumber
3. Separate Lumber by Kiln Sticks When Stacking
4. Use Stick Guides for Proper Alignment of Kiln Sticks
5. Improve Boiler Efficiency
6. Improve Drying Kiln Efficiency
7. Improve Kiln Drying by Using High Speed or Variable Speed Fans
8. Dehumidification Drying
9. Air Vacuum Drying
10. Vacuum Resistance Drying
11. Vacuum Press Drying
12. Radio Frequency (RF) Redrying of Veneer
13. Provide Adequate Dry Shed Capacity and Environment

Opportunities

Opportunity 1

Arrange Lumber Delivery to Minimize Inventory and Storage Time.

The longer that delivered lumber stays in the lumber yard, the more chance of degradation resulting from exposure to the environment or damage (breaking, cracking, etc.) from inadvertent contact with equipment or other lumber. Sometimes, excessive quantities of lumber are purchased because of lower prices, however the money saved up front can be lost through damaged lumber that is eventually wasted. Plan carefully so that lumber in your yard maintains the desired quality and is utilized efficiently.

Benefits

- conservation of raw materials, less lumber waste

References: 24

Inspect and Sort Lumber.

Many times, lumber is shipped in packages with a random mixture of lengths - 6, 8, 10, 12, 14 and 16 feet. It is recommended that the incoming lumber be inspected and sorted by length, thickness, and quality to reduce wood waste.

Lumber that is received below the quality grade requested, or is poor quality, can be identified promptly and returned to the supplier or used appropriately. Also, yard space and drying kiln space can be utilized more efficiently by the elimination of large voids in the packages resulting from mixed board lengths. Mixed lengths will also cause improperly supported stacks and associated drying defects, and potentially damaged lumber caused by the movement of lumber packages with protruding boards.

Sorting can be done by hand or by mechanical sorters. The investment in mechanical sorting can be significant. Hand sorting is less capital intensive. Sorting will result in energy savings by increasing kiln space utilization, improving the quality of lumber and generating less waste which will more than offset the cost of sorting.

Modern manufacturing concepts recommend a close partnership with suppliers which encourages more shared responsibility and trust. This partnership can eliminate costly, non value-added steps such as inspection and reshuffling materials. Quality programs which document out-of-spec materials will give both the supplier and the customer the facts to measure and improve performance. Train suppliers as you would your own inspectors so that they know and meet your needs. Consider pre-shipment inspections and "custom" shipments that are one length, one grade, etc., so that costly additional steps after receiving are avoided.

Benefits

- conservation of raw material
- less lumber damage and waste
- lumber that meets quality expectations
- efficient space utilization
- improved productivity

References: 24

Separate Lumber by Kiln Sticks When Stacking.

Most lumber is received in stacked "packages" that are "dead hacked", or stacked board - to - board with no air space between boards. If the lumber remains this way, no drying will take place. This will result in lumber that is not dry enough for use, and stains and rot will occur, resulting in wasted lumber.

As the lumber is inspected and sorted, restacking must occur. It is recommended that "kiln sticks", or relatively small stick separators (e.g., 8' long x 1-1/2" wide x 1" thick) be used to place the lumber in layers. This practice separates the boards in a package of uniform size that corresponds to the size of the dry kilns and lumber lifts to be used later. Air movement around the lumber allows it to dry and prevents staining and rotting that results in wasted wood.

Benefits

- conservation of raw materials
- less lumber damage and waste
- improved drying

References: 24

Use Stick Guides for the Proper Alignment of Kiln Sticks

One of the most important factors in the stacking of lumber is to get perfect alignment of the kiln sticks. As packages of stacked lumber are placed on top of each other, considerable weight is put on the bottom lumber. If the kiln sticks are not perfectly aligned, deformation of the wood can occur, making it unsuitable for quality furniture and creating waste.

"Stick guides" can be used to align the sticks to the recommended spacing as listed in the following table.

Thickness of Lumber	Spacing of Kiln Sticks
5/8	12” - 18”
4/4	18” - 24”
5/4	24”
6/4	24”
8/4	24”

Benefits

- conservation of raw materials
- less lumber damage and waste
- improved drying

References: 24

Improve Boiler Efficiency.

Heat that is generated by the boiler can be lost through many avenues such as

- pipes, valve and trap leaks,
- inadequate insulation on boiler and pipe surfaces,
- inefficient fuel burning,
- dirty heat transfer surfaces,
- inadequate condensate return to boiler,
- poor boiler water treatment,
- poor steam pressure,
- pressure reduction valves,
- high moisture content in the wood waste fuel,
- poor fire and combustion air, and
- inadequate maintenance.

Loss of heat not only results in a higher cost of fuel or electricity for the operation, but also provides additional pollution in the form of air emissions to the environment.

Many states and local power companies offer programs to help conserve energy through energy efficiency programs. Energy conservation experts will visit your site and look for opportunities to conserve energy. Most of these programs are provided at no cost and can improve the energy efficiency of your operations resulting in considerable cost savings and pollution prevention.

Call your local utility or state pollution prevention program to find out more. See the Waste Reduction Resources section for the program in your state, or call the Waste Reduction Resource Center at 1- 800 - 476 - 8686.

Benefits

- energy conservation
- reduced energy costs
- reduced air emissions

References: 24

Opportunity 6

Improve Drying Kiln Efficiency

Operate drying kilns at capacities that result in the best efficiency. Filling a kiln too full of lumber may prevent adequate air movement and cause inadequate drying or increased drying times. This results in wasted energy, increased air emissions and higher costs. Utilizing the kiln at low capacities (e.g., 10 - 50%) may provide for adequate air movement and fast drying times, however it will also result in wasted energy and higher costs, as the kiln operation may not be optimal.

Keeping records on kiln process control will provide information that contributes to continuous improvement and quality.

Benefits

- energy conservation
- reduced air emissions
- reduced costs
- improved yield

References: 24

Improve Kiln Drying by Using High Speed or Variable Speed Fans

Increasing air velocities typically from 350 feet per minute to 800 to 1200 feet per minute will result in drying times that are two to three times faster when used in steam kilns. Higher quality lumber is produced and the steam energy savings can offset the increased power costs.

Another technique that maximizes energy efficiency is enabling the fan speed to be adjusted for the need. During the initial phase of drying when moisture is readily available, the fans are run at high speeds. Later, when water diffuses from the wood more slowly, the fan speed is reduced without reducing the drying rate. Computerized controls can be applied to the variable speed fans to optimize air flow as conditions change.

Benefits

- improved lumber quality and less waste
- energy savings
- reduction of boiler air emissions

Watch-Outs

- condenser corrosion from acidic condensate
- status: technology transfer stage

References: 8, 9

Dehumidification Drying

Where steam capacity is unavailable, or where boilers are prohibited because of air pollution regulations (i.e., Pacific northwest), dehumidification can be economical. Electric heat pumps can be used to dry the lumber with less cracking or warpage than conventional drying methods.

Lumber to be dried is placed in a drying building or kiln where heated air takes the moisture out of the wood. The moisture saturated air is then circulated via ducts to heat pumps that condense the moisture and remove it from the air. The air is then re-heated and passed back over the lumber. Utilizing the same air provides precise control of temperature and humidity and prevents drastic temperature fluctuations.

Benefits

- improved lumber quality and less waste
- potential energy savings
- elimination of boiler emissions

Watch-Outs

- condenser corrosion from acidic condensate
- status: technology transfer stage

References: 8, 9

Opportunity 9

Air Vacuum Drying

Alternating steam derived hot air with a vacuum is available commercially for lumber drying applications ranging from 2,000 to 14,000 board-feet capacities. Drying times are about one-tenth of steam kilns. Vacuum dryers are most economical for wood fabricators using high value hardwoods.

Benefits

- potential energy savings

Watch-Outs

- status: technology transfer stage

References: 8, 9

Opportunity 10

Vacuum Resistance Drying

This technology uses electrical resistance blankets to provide heat between the layers of wood in the kiln. Capacity is approximately 2,000 board-feet with drying times significantly reduced over conventional steam kilns.

Benefits

- potential energy savings

Watch-Outs

- status: technology transfer stage

References: 8, 9

Opportunity 11

Vacuum Press Drying

This technology is applicable to straight lumber which is free of side bend , cup or twist in batches less than 1,000 board-feet. Lumber is dried under 1,800 pounds per square foot of mechanical pressure in a vacuum chamber. Heat is provided by a self-contained hot water unit. After drying, pressure is maintained during cooling, resulting in flat, stress-free lumber.

Benefits

- improved lumber quality and less waste
- potential energy savings

Watch-Outs

- status: technology transfer stage

References: 8, 9

Opportunity 12

Radio Frequency (RF) Redrying of Veneer

Conventional redrying of plywood veneer typically results in 15% to 20% breakage rate and overdrying. RF redrying provides moisture redistribution from wet spots to overdried areas, thus controlling moisture profile and minimizing breakage. A two year payback is estimated for a $1 million dollar investment for operations with high redry losses as well as plants with limited drying capacity.

Benefits

- improved veneer quality, less breakage and waste
- potential energy savings

Watch-Outs

- status: technology transfer stage

References: 8, 9

Opportunity 13

Provide Adequate Dry Shed Capacity and Environment.

Significant cost and effort have gone into adequately drying the lumber produced by the drying kiln, therefore it is important to protect it. Dried lumber that is exposed to the weather and potentially damaging yard activities can change quality lumber to waste wood.

If not immediately used, kiln dried lumber needs to be stored in an enclosed dry shed where it is protected from the weather. Also, if the lumber is stored long term (several months), a controlled environment is recommended to prevent deterioration.

References: 24

2 Rough End and Gluing

Process Description

The typical functions of rough end and gluing include:

- cutting
- sawing
- gluing and joining

The purpose of the rough end and gluing is to remove defects convert the dried rough lumber into rectangular shapes or "blanks" of lumber or veneer that will be used to make the furniture components.

Rough End and Gluing Wastes

- wood
- sawdust
- glue
- volatile air emissions

Opportunity Summary

The following are opportunities for waste reduction in Rough End and Gluing. Summaries of these opportunities follow.

1. Remove Defects from Rough Lumber Efficiently

2. Finger Jointing

3. Recycle Wood Waste and Sawdust

4. Use the Proper Glue

5. Use Proper Gluing Techniques

Opportunities

Opportunity 1

Remove Defects from Rough Lumber Efficiently.

Significant wood can be saved if care is taken when removing defects as the rough lumber is cut. Combining the cutting of multiple long and short lengths on the same rough lumber board will improve yield and reduce wood waste. New equipment and technology such as “rip first” methodology, automatic board advancing, and computerized vision scanning to identify defects and cutting patterns are being developed and applied.

Benefits

- improved yield
- less wood waste

References: 8, 9, 24

Opportunity 2

Finger Jointing

Finger jointing is the joining of two short sticks or boards end-to-end to form a longer one resulting in less waste and better material utilization. The pieces are joined and glued end-to-end by a finger joint. Any piece five inches or longer can be used. There is equipment available that can machine the joints, apply the glue and press the pieces together. For circumstances where areas are not exposed in the final product, the finger jointing process can provide significant increases in material utilization, and thus less wood waste.

Equipment is available to quickly cure glued joints using penetration heating devices such as radio frequency fields which many times can speed the curing and improve the quality of the joint.

Benefits

- improved yield
- less wood waste

References: 24

Opportunity 3

Recycle Wood Waste and Sawdust

For many years wood waste was open burned or disposed of in landfills . As the cost of both wood and disposal will continue to rise, and open burning is usually no longer an option, it makes sense to find ways to recycle wood waste. Recycling options include:

- use in particle board, chipcore, laminates
- absorptive materials
- shredding or grinding to use as animal bedding, sludge stabilizer, mulch or decorative landscaping material (this also reduces the volume for storage until use)
- use in pulp and paper manufacturing (usually softwood only)
- using as fuel for energy and heat recovery either for on-site or off-site energy recovery facilities where other sources of waste wood can be combined

Benefits

- efficient use of raw materials
- reduction of wood wastes

Watch-Outs

- some wood wastes need to be dried or pelletized before being used as fuel which adds equipment and expense
- burning treated or coated wood can release regulated hazardous air pollutants
- be familiar with applicable regulations before installing and operating a wood boiler
- waste streams should not be combined (i.e., mixing sawdust, wood chips, end pieces, etc.) as it may inhibit secondary use

References: 35

Opportunity 4

Use the Proper Glue

Using the wrong glue can result in wasted material and time. Some glues are non-reversible, once they are cured, they cannot be liquefied again. If the desired quality of the bond is not achieved, the material may end up in the scrap pile.

Glues come in basic categories:

- natural glues (animal, starch, casein)
- synthetic resins including thermoplastic (polyvinyl acetate or PVA) used in assembly and edge gluing, and thermosetting (urea formaldehyde and other formaldehydes) used for plywood and edge gluing
- specialty adhesives (contact, hot melt) used in edge bonding

Benefits

- reduced wood and glue wastes
- improved yield

Watch-Outs

- The shelf life and pot life of glues vary. Be sure to know the shelf life before purchasing or catalyzing large quantities as they could end up as waste.
- PVA is more expensive than urea, however it is better suited for certain applications
- Urea formaldehyde resins are sources of formaldehyde emissions; discuss with suppliers to obtain the lowest emitting resin that can do the job
- compliance with OSHA and EPA regulations

References: 24

Utilize Proper Gluing Techniques.

Improper gluing techniques can lead to inefficient material use and waste. When gluing two pieces of wood together, four steps are necessary - application, transfer, wetting, and cure. After applying the glue to one piece, transfer of the glue to the other piece must take place while the glue is still able to flow and thoroughly wet the surface of the other piece. Using glue spreaders provide a consistent layer thickness. Some wood species resist wetting more than others, so the speed of the gluing process must be controlled.

Curing is the solidification of the glue and must start after wetting and be complete before the assembly is removed from the press and the joint is subjected to stress. Selecting the proper curing technique (e.g., air dry, reactive, radio frequency heating, resistant heating hot melt, etc.) is also important.

Keep glue containers covered whenever possible to prevent chemical vapors from escaping.

Periodic maintenance and calibration (where possible) of glue applicators provides proper transfer and prevents waste.

Benefits

- reduced wood and glue wastes
- improved yield

References: 24

3 Machining and Sanding, Assembly

Process Description

The typical operations of machining and sanding include:

- planing
- moulding
- shaping
- cutting
- tenoning

Machining, or sometimes called the finish machine room, shapes the rectangular strips produced by the rough end and the plywood produced by veneering and laminating into the finished dimensions specified for the furniture part.
Sanding is basically rubbing the wood with an abrasive to smooth or prepare the surface for subsequent finishing or coating steps. Sanding can be done by hand or with sanding machinery. Sanding can take place on parts before furniture assembly, or take place during finishing in between coating steps.

Machining and Sanding Wastes

- wood, sawdust
- sanding belts
- machine tools

The typical operations found in Assembly are:

- assembly - putting parts together to make the final piece of furniture
- fitting - making components of the furniture piece fit (ie., drawers or doors) by adjusting the dimensions, stops, or hinges by machining or sanding
- repairing - all exposed surfaces are repaired of rough spots and defects that affect the finish such as glue spots, raised grain, dents, cross sand scratches
- inspection - a check to see if the furniture piece is ready for finishing

Assembly, or sometimes known as the cabinet room, takes the parts produced by previous operations and assembles them to make furniture. Component parts are glued, screwed, stapled, and nailed together to make the furniture.

Assembly Wastes

- wood waste
- spent glue
- volatile air emissions from the glue
- bolts, nails, staples

Opportunity Summary

The following are opportunities for waste reduction in Machining and Sanding. Summaries of these opportunities follow.

1. Use Segmented Polishing Platens
2. Cleaning Sanding Belts and Machine Tools
3. Dust Collection
4. Recycling Wood Waste and Sawdust (see Section 2, Opportunity 3)

The following are opportunities for waste reduction in Assembly.

5. Use the Proper Glue (see Section 2, Opportunity 4)
6. Use Proper Gluing Techniques (see Section 2, Opportunity 5)
7. Recycling Wood Waste and Sawdust (see Section 2, Opportunity 3)

Opportunities

Opportunity 1

Use Segmented Polishing Platens

Sanding with minimal stock removal is important as the cost of lumber, veneers, and waste management and disposal continue to grow. Using segmented platens provides an opportunity to leave more wood on the piece being sanded.

Using segmented platens on sanding equipment, controlled electronically or pneumatically, will provide more sensitivity and efficiency. For example, sanding with air pressure helps dissipate heat, allowing a more uniform finish at a higher grit without varnishing. The electronic platen is more sensitive, but the pneumatic sanding platen is less expensive.

Benefits

- reduced wood waste
- improved efficiency

References: 35

Opportunity 2

Cleaning Sanding Belts and Machine Tools

Cleaning sanding belts by either commercial belt cleaner or steam will extend the life of the belt. Also cleaning saws and other tools of resin build-up preserves tool life.

Benefits

- longer tool and belt life
- reduced waste

Dust Collection

As wood parts are machined and sanded, a substantial amount of sawdust is generated. Dust collection systems can provide safety and waste reduction benefits, but must be properly designed to be effective, safe and efficient. Adequate face and collection velocities are necessary for collection orifices, and appropriate velocities in the ventilation ducts must be provided to prevent particulate settling. Energy efficient systems have dampers to cut off branches that are not needed. Filters, bag houses, and cyclones are examples of mechanisms to separate the dust from the exhausted air.

Benefits

- improves worker health and safety by keeping the dust out of the breathing air and off the floor
- improves sanding efficiency by preventing dust from becoming embedded in the sanding belt
- extends equipment life and decreases maintenance by keeping dust away from machinery
- collects and keeps the sawdust from becoming contaminated with dirt and other contaminants so that it can be recycled

Watch-Outs

- consult an industrial ventilation design manual or obtain assistance from a qualified engineer to assure that the system is safe, effective and energy efficient

References: 35

4 Finishing

Process Description

The basic operations of the typical finishing process include:

- glue sizing or bleaching
- cleaning / stripping
- coating
- drying
- sanding
- rubbing / buffing
- equipment cleaning
- repair / touch-up

The purpose of the finishing operations is to provide the furniture with a pleasing appearance, a feeling of smoothness, and protection of the wood.

Finishing Wastes

- volatile organic compound (VOC) emissions and hazardous air pollutants (HAP) emissions
- liquid wastes including spent stains, washcoats, fillers, sealers, glazes, topcoats, solvents, wastewater
- solid wastes including spray booth filters, overspray solids, rags, solvent still bottoms
- energy

Opportunity Summary

The following are opportunities for waste reduction in Finishing. Summaries of these opportunities follow.

Coating Formulations

1. Use of Waterborne Coatings
2. Use of High Solids Solvent Based Coatings
3. Use of Polyester / Polyurethane Based Coatings
4. Use of CO_2 Based System Coatings
5. Use of Radiant Cured Coatings

Application Technology

6. Use of High Volume Low Pressure (HVLP) Spray
7. Use of Airless Spray
8. Use of Air - Assisted Airless Spray
9. Use of Electrostatic Technology
10. Use of Vacuum Coating
11. Use of Dip Coating
12. Use of Flow Coating
13. Use of Roll Coating
14. Use of Curtain Coating

Opportunity Summary (continued)

Cleaning / Stripping

15 Alternatives to Methylene Chloride Strippers

Operation and Maintenance

16. Train Equipment Operators
17. Prepare Coatings Properly
18. Direct Delivery of Coating to Spray Gun
19. Use Heat to Obtain Desired Coating Viscosity
20. Caring for Spray Equipment
21. Equipment Cleaning
22. Inventory Management
23. Recycling of Finishing Materials

Coating Formulations

Table 4-1 VOC and Solids Content of Commercial Coatings

Formulation	Approximate Volatile Organic Compound Content (lb./gal - water)	Solids Content (percent by volume)
Nitrocellulose	6.0	16
Aqueous	2.3	26 - 30
Polyester (styrene based)	negligible	100
Polyester	3.0	30 -50
Polyurethane	3.4	30 - 50
CO2 Based System	4.7	33.5
UV Curable	3.1	56

References: 6

Use of Waterborne Coatings

Water, instead of conventional solvents is the major carrying medium for the coating solids in waterborne coatings. Therefore using waterborne coatings, or "hybrid" coatings with a combination of water and conventional solvents, can significantly reduce VOC air emissions and reduce other associated liquid and solid wastes.

Benefits

- reduced air emissions and hazardous liquid and solid wastes
- finish resists moisture, chemicals, impact and abrasion well
- adaptable to a wide range of conventional application methods
- in some cases equipment can be cleaned with soap and water
- potential reduction in fire insurance when converting from solvent (VOC) coatings to waterborne
- in some cases reduced toxicity and odor

Watch-Outs

- increased drying times, large drying air requirements, or higher oven temperatures as water takes more time than VOCs to evaporate, especially in high humidity
- for proper solubility and freeze protection must be stored at room temperature
- equipment may need to be cleaned immediately after use
- equipment must be corrosion resistant (e.g., plastic, stainless steel)
- moisture content of substrate and finish room humidity must be controlled
- wood grain raising a potential
- wood surface must be free of oils and dust for good adherence properties
- high gloss finish sometimes difficult to obtain; increased rubbing effort needed
- some atomization difficulties, increased runs and sags, tendency to foam
- refinishing is sometimes difficult
- costs of conversion to corrosion resistant equipment can be significant
- carefully review MACT standard

References: 5, 6, 18, 20, 28, 36

Case Study 1-A
New England Woodcraft
Forest Dale, VT

In 1987, New England Woodcraft, a manufacturer of bedroom and lounge furniture, installed a continuous finishing line that can apply clear, water-based sealers and topcoats for their flat furniture pieces. Sealing steps include spraying, flashoff, infrared heating, followed by hand sanding. Pieces then make their way to the topcoat spray booth, another set of flashoff and infrared ovens, and then final fans. After three years of testing water-based emulsion finishes with C. E. Bradley Laboratories of Brattleboro, VT, the company completely converted its finishing line to water based acrylic clear sealers and topcoats.

Results not only included a pleasing, high quality finish with excellent performance, but also the reduction of VOC emission rates by 80% and insurance costs by 25%. Even though the water-based formulations cost more than nitrocellulose, a Woodcraft representative states that they get "more mileage" from the water-based formulations because of the higher solids content.

References: 11

Use of High Solids Solvent Based Coatings

These coatings are solvent-based, however they have a high solids concentration in the range of 35% - 40% solids which results in an increased application of coating with less VOC emissions and solvent waste. There are three basic types of high solids coatings - two component ambient temperature cured, one component heat converted, and high solids thermoplastic solventborne coatings.

Benefits

- reduced air emissions and less liquid and solid wastes
- less compliance and disposal costs
- less material required to coat, reduced solvent usage and costs
- reduced number of spray applications to achieve the same coating thickness
- high transfer efficiency
- reduced inventory, less handling and shipping costs, additional floor space
- in some cases less fire risk, potential reduction in fire insurance

Watch-Outs

- cannot be used effectively in dip or flow coating applications
- wood surface must be clean
- may require high temperature curing with narrow "time/temperature/cure window"
- difficulty in controlling film thickness and sagging; may require heater
- sensitive to ambient temperature and humidity
- finished piece difficult to repair
- overspray is tacky and difficult to clean
- reduced shelf life, short pot life for two component coating
- odor and slow flashoff - use covered flashoff zones

References: 5, 6, 18, 20, 28, 36

Use of Polyester / Polyurethane Based Coatings

Polyester-based and polyurethane-based coatings are used significantly outside the U.S. Use of these coatings can result in a reduction of VOC air emissions over nitrocellulose solvent-based coatings. Polyester-based coatings include styrene derived polyester of 100% solids which is cured by ultraviolet (UV) radiation, and acrylic polyesters (30 to 50% solids) which are cured by catalytic reaction or UV radiation. These coatings are typically applied by conventional spray guns or flat line applicators. Curing may require an initiator such as organic peroxide or UV radiation.

Benefits

- reduction in solvent usage and associated costs
- reduction in VOC air emissions, solvent wastes and associated compliance and disposal costs
- fast drying, less floor space needed
- durable finish
- resistant to heat, chemicals, impact
- high gloss with polyurethane
- multiple application methods

Watch-Outs

- may require a clean room
- piece coated difficult to repair
- polyester is chemically incompatible with nitrocellulose materials, can not be used in the same system or on the same piece - potentially explosive
- pot life is short (1 to 6 hours)
- respiratory protection may be required (potential exposure to isocyanates)
- UV radiation curing may be difficult for non-flat surfaces since energy transfer is along "line of sight"
- some users report "plastic" looking finish

References: 5, 6, 18, 20, 28, 36

Use of CO_2 Based Coatings

In this system, super critical carbon dioxide is used to decrease viscosity and enhance atomization and replaces all or a substantial amount of the solvents used in the conventional spray application of coatings. The system's specially designed airless spray guns and nozzles enables the resin concentrate to be mixed with the carbon dioxide. The coating cures by air drying or baking. The use of CO2 based coatings can reduce VOC emissions by 50% over nitrocellulose solvent-based coatings.

Benefits

- reduction in solvent usage and associated costs
- reduction in VOC air emissions, solvent wastes and associated compliance and disposal costs
- reduced worker exposure
- high quality finish
- high solids content
- nitrocellulose resins can be used and do not need reformulation
- fewer coating applications needed
- high transfer efficiency
- sometimes reduces sanding requirements
- easy to repair

Watch-Outs

- limited suppliers of system equipment
- technology still in the developmental stage with limited experience
- lower fluid delivery rates than air spray guns
- gun and tubing is bulky
- royalty costs
- use of equipment requires training

References: 5, 6, 18, 20, 28, 36

Case Study
Pennsylvania House
White Deer, PA

The Pennsylvania House manufacturing facility in White Deer, PA is applying the UNICARB™ spray finishing system full time for lacquer topcoats on chairs. Starting in the Spring of 1990, Pennsylvania House worked with Union Carbide (licenser of the UNICARB™ system), Nordson (developer of the spray equipment) and Guardsman Product Inc. (formulator of the topcoat lacquer) in the development of the system which was installed on the chair finishing line in July of 1991.

Results include a topcoat finish of equivalent quality and integrity to the finish previously provided by the air assisted airless spray guns, however with only about half as many gallons of lacquer used. VOC emissions have been reduced by approximately 70%.

References: 4

Case Study
UNICARB™ Coating Application

A wood furniture manufacturer of occasional furniture conducted a trial of the UNICARB™ technology for the purpose of eliminating hazardous air pollutants associated with the sealers and topcoats that they had been using. New UNICARB™ topcoats and sealers were formulated to reduce hazardous air pollutants and the system was applied.

Results included a 50% reduction in material usage, the elimination of one coating application, the finish quality was improved and less rework was necessary. VOC emissions were reduced by 65% and the company estimated a less than one year payback for the UNICARB™ system with potential annual savings of $ 125,000. The manufacturer is still testing the technology.

References: 37

Use of Radiant Cured Coatings

The physical and chemical properties of a coating are altered by ultraviolet (UV), electric beam (EB), or infrared (IR) radiation so that a rapid polymerization takes place. In general, radiation cured coatings require less energy, less time to cure, and contain less VOCs than conventional coatings. Common radiation cured coatings include acrylate based materials and epoxies.

Benefits

- very high solids content
- reduction in solvent usage and associated costs
- reduction in air emissions, solvent wastes and associated disposal costs
- reduced energy costs
- high film thickness, fewer coats needed
- durable and glossy finish
- increased production rates, short curing times
- small ovens
- UV systems are easily installed / retrofitted
- low air movement reduces dust contamination

Watch-Outs

- necessity of automation
- design changes usually require significant modification
- finished pieces difficult to repair
- not applicable to coatings which contain pigments (e.g., stain)
- higher capital investment than conventional ovens
- higher cost for UV and EB coatings
- potential toxicity of coating constituents, dermatitis
- shrinkage / adhesion problems with acrylate
- curing three dimensional pieces is difficult
- may require a clean room
- some "plastic" looking finishes reported by users

References: 5, 6, 18, 20, 28, 36

Case Study
Loewenstein
Pompano Beach, FL

Loewenstein is a seating manufacturer that finishes over 250 varieties of chairs. Late in 1987, it was ordered to reduce its annual VOC emissions (290,000 lbs.) by 31% with a deadline of February 1, 1989. By April of 1989 Loewenstein had reduced its annual emissions to 165,000 lbs, and as of March 1993, they were down to 75,000 lbs. per year.

This reduction is a result of changing from their previous sealer and topcoat with 16% solids to a epoxy acrylate UV sealer and topcoat 68% solids.

They have also switched to non-electrostatic HVLP guns for stain touch up and electrostatic HVLP guns for sealer and topcoat applications.

Other benefits included improved film properties and appearance, less coatings to achieve the desired film thickness, early sealer film hardness that permits extensive sanding without wearing through the coating.

References: 21

Table 4 -2 Summary of Spray Application Methods

Spray Application Method	**Comparable Transfer Efficiency**	**Atomization Quality**	**Categories of Coating Applied**
Conventional Air	low	very fine	solvent borne waterborne
High Volume, Low Pressure	medium to high	fine	UV-curable solvent borne waterborne high solids
Airless	low	coarse	solvent borne waterborne
Air Assisted Airless	low to medium	fine	solvent borne waterborne high solids
Electrostatic	high	fine	solvent borne high solids powder coat waterborne UV curable

References: 6

Use of High Volume, Low Pressure (HVLP) Spray

HVLP spray guns atomize materials with warm, dry air between 0.1 and 10 psi, while conventional spray guns usually atomize materials at 60 to 100 psi. The low pressure air of HVLP systems transfers the coating to the substrate with low velocity and prevents the rapid expansion of spray caused by higher pressure guns, resulting in less overspray, less bounce back, and better transfer efficiency (40 -70%).

Benefits

- increased transfer efficiency, reduced overspray
- reduced worker exposure from bounce back
- reduced VOC air emissions
- lower booth clean-up costs
- reduced filter replacement costs
- decreased booth wastewater treatment costs
- sprays well into cavities and recesses
- can be used for a variety of coatings (e.g., waterborne, high solids)
- finish as good as conventional spray guns with low to medium viscosity coatings

Watch-Outs

- less complete atomization, atomization may not be sufficient for fine finishes
- slower application rate, high production rates may be affected
- worker training is a must for success

References: 5, 6, 18, 20, 28, 36

Case Study
Tiz's Door Sales (TDS)
Everett, WA

TDS manufactures wood products including interior and exterior doors and frames, window and base moldings, and stained railings. HVLP spray guns were purchased to replace conventional spray guns on manual spray lines which were about 20% efficient. Along with the conversion to HVLP, TDS also installed automated flatline spray equipment which increased application efficiency and recycled overspray, switched from toluene-based coatings to less hazardous coatings, provides heat instead of solvents to thin coatings, uses dedicated pumps and lines for each type of coating, blocks gun nozzles and blows air back through the guns and delivery systems to reduce waste during cleaning.

TDS has reduced coating use by one-half (1991 - 18,000 gallons saved ~ $ 180,000) and experienced significant savings in labor and waste disposal costs.

References: 36

Case Study
Henredon Furniture
Morgantown, NC

Henredon Furniture converted from conventional spray guns to HVLP spray equipment (7 to 10 psi) for applying lacquers, sealers, and stains to chairs and benches. Spray operators received training on operation of the new equipment.

The company realized a savings of $120,000 per year from a 13 to 15% reduction in coating usage. Product quality improved without impact to line speed and VOC emissions were reduced by over 126,000 lbs. Purchase and installation of the spray guns ranged from $350 to $500 per gun. Payback period was 3.5 months.

References: 25

Case Study
Alexvale Furniture
Taylorsville, NC

Alexvale Furniture converted from conventional spray equipment to HVLP. The excessive overspray from the conventional equipment resulted in large quantities of hazardous waste from spray booth clean-out and filter replacement.

The HVLP equipment reduced hazardous waste generation by forty 55 gallon drums per year with cost savings estimated at $ 50,000 and payback period less than one week.

References: 37

Case Study
Thomson Crown Wood Products
Mocksville, NC

Wood and wood finished television cabinets are manufactured by Thomson Crown. Parts of these cabinets were coated with air-assisted airless spray guns (high air pressure up to 55 psi) with a poor transfer efficiency and a high generation rate of VOC emissions and coating waste. HVLP spray guns were purchased to replace the existing guns.

Material reductions of 65% for equalizer, 65% for toner, 35% for glaze, 35% for no-wipe, and 53% for water-based black finishes that total 13,300 gallons per year that have been realized. $ 137,448 is the estimated savings, plus the costs associated with reduced wastes. The cost of the project was $ 21,350.

References: 25

Case Study
Ethan Allen, Inc.
Old Fort, NC

Ethan Allen, who manufactures dining and bedroom furniture, replaced air assisted spray guns with HVLP equipment. Each operator is required to attend annual technical training provided by the spray gun manufacturer.

Spraying efficiency has increased and the quantity of overspray to be filtered has been reduced. The investment was $ 3000 (12 guns @ $ 250). Materials were reduced by $ 15,000 to $ 20,000 per year, plus costs associated with waste management and disposal were realized.

References: 25

Opportunity 7

Use of Airless Spray

Airless spray systems atomize the coating by increasing the coating's fluid pressure (ranges from 500 to 6500 psi) without introducing a pressurized air flow.

Benefits

- high transfer efficiency (35 - 65%)
- reduced coating usage
- reduced air emissions and wastes
- high rates of paint flow, can move gun faster
- greater productivity, less operator fatigue
- ability to apply highly viscous fluids
- no air hose providing increased gun handling versatility

Watch-Outs

- reduced spray pattern
- relatively poor atomization
- expensive nozzles
- coatings limitation
- tip plugging
- danger of skin injection
- increased training and maintenance

References: 5, 6, 18, 20, 28, 36

Opportunity 8

Use of Air - Assisted Airless Spray

Air-assisted airless spraying combines compressed air atomization with airless atomization. About 85% of the atomization of the coating is provided by fluid pressure (150 - 800 psi) as in airless, and the remaining 15% is provided by air pressure (5 - 30 psi) supplied at the nozzle.

Benefits

- high transfer efficiency relative to conventional (40 - 70%)
- finish comparable to conventional spray
- reduced material usage
- less overspray and bounceback

Watch-Outs

- not compatible with some high solids coatings
- risk of skin injection
- increased maintenance
- increased operator training
- capital cost

References: 5, 6, 18, 20, 28, 36

Use of Electrostatic Technology

During electrostatic coating, coating particles are given a negative electric charge and the piece to be finished is either grounded or is given a positive charge. This electrostatic action causes the coating particle to be drawn to the piece creating a high transfer efficiency of 35 - 70% for spray guns, and 60 - 90% for rotary disk (centrifugal force) applicators. This allows each piece to be coated with fewer passes and less coating material and associated waste. The particle velocity and electrostatic charge must be balanced to achieve optimum coating.

Benefits

- high transfer efficiency
- reduced material usage and associated VOC emissions and waste
- uniform film thickness
- good wrap around coating and edge cover
- can apply a variety of coatings (e.g., solvent-based, high solids, water-based, radiation curable)

Watch-Outs

- pieces sometimes need to be coated by humidity sensitizing agent as pieces must be conductive
- safety/fire risk
- extra cleanliness essential
- coating accumulation at high points and "skips" (uncoated areas) in corners caused by Faraday effect may require touch-up
- bulky and delicate spray guns
- relatively high cost

References: 5, 6, 18, 20, 28, 36

Case Study
Broyhill Furniture Industries
Conover Plant

In December 1983, Broyhill installed an electrostatic finishing system in their Conover chair plant in order to obtain a better quality finish and reduce material and labor costs. The new system, which uses five electrostatic high speed reciprocating turbo disks, replaced a conventional spray system. The system also includes a flow coater that applies a sensitizer to make the surface of the chairs stain-conductive, and two non - grain raising stain spray booths.

After the system had been operating for two years, it was determined that material costs were reduced by 25% and the new system eliminated the need for six employees, who were relocated into different jobs at the plant. Associated wastes were also reduced and the payback period for the system was less than two years.

References: 18

Case Study
SunTui
St. Paul, MN

In 1992, Sun Tui, which manufactures futons, installed an automated electrostatic spray line that applies waterborne coatings to futon frames. The system replaced conventional air spray equipment that applied waterbased coatings. The system includes a conveyor line, a photosensitive light curtain that communicates piece size information to the spray guns, water spray guns to add humidity to the piece for better conductivity, electrostatic bells which apply the coating, and an infrared oven.

Results have included increasing transfer efficiency 30 - 35% over the conventional system, less overspray and wasted material, and less VOC emissions.

References: 3

Case Study
Thomasville Furniture
Thomasville, NC

Thomasville Furniture was realizing a 80% loss of finishing materials (20% transfer efficiency) from their conventional air spray guns on their chair finishing line. In 1979, the company installed five hand-held airless electrostatic sprayers in an effort to reduce the amount of material wasted.

Clean up of the spray booth is now conducted once a week instead of once per day. Material waste was reduced to 30% - 40% and associated wastes and VOC emissions were reduced. The walls of the spray booth are grounded so that overspray is attracted to the walls keeping the remainder of the area clean. The greatest savings occurred in the lines wiping stain process where stain usage was reduced from 12 ounces per chair (dipping process) to 3 ounces per chair. In spite of some difficulties with humidity problems and higher coating prices, a payback period of one year was realized.

References: 18

Use of Vacuum Coating

In vacuum coating, pieces are passed through a coating chamber under a vacuum. Coating material fills the chamber and the piece is coated as it proceeds through the chamber. As the piece leaves the chamber, an air jet removes excess finish. The film thickness is controlled by varying the coating viscosity, the magnitude of the vacuum and the velocity of the air jet. The technology has been limited to pieces possessing the same silhouette along the entire length of the piece. In theory, there is no wasted material as excess material is recycled within the chamber. For waterbase coatings, however, there can be some build up of solid coating on resevoir walls and other parts that will require cleaning.

Benefits

- excellent transfer efficiency (~ 100%)
- waste and VOC emissions essentially eliminated
- high production rates
- low labor costs

Watch-Outs

- piece must have uniform silhouette
- primary use for waterborne coatings
- thinners and water can be removed from the coating by the vacuum causing viscosity adjustments
- some tendency to foam

References: 36

Use of Dip Coating

Parts are coated by dipping them into a tank of coating material. This provides better coverage and causes less waste than conventional air spray systems. Dipping can be manual or pieces can be loaded onto a conveyor that dips the piece into the tank. Excess coating drips off the piece and drains back into the tank. Viscosity must be optimized for desired coating thickness. If solvent-based coatings are being applied, the system should be enclosed to prevent VOC emissions from escaping the tank.

Benefits

- excellent transfer efficiency
- reduced wastes
- low labor requirements
- high production rates

Watch-Outs

- finish is coating viscosity sensitive
- not suitable for pieces with hollows or cavities
- color change is difficult and slow
- appearance is poor to fair compared to spray finishes

References: 6, 28, 36

Opportunity 12

Use of Flow Coating

In flow coating, many separate streams (10 to 80) of coating are directed at the surfaces of the piece as it passes through the flow coating chamber.

Benefits

- high transfer efficiency
- reduced wastes
- high production rates
- low labor requirements
- low installation costs

Watch-Outs

- poor to fair finish appearance
- coating viscosity controls film thickness

References: 6, 28, 36

Opportunity 13

Use of Curtain Coating

Curtain coating coats flat pieces by moving the pieces through a continuous flowing "waterfall" of coating material. The coating material flows at a controlled rate from a reservoir onto the pieces which are conveyed through the stream at high rates of speed. The excess coating material is trapped in a reservoir and recirculated with minimal waste.

Benefits

- excellent transfer efficiency
- reduced wastes
- very high production rates
- uniform coating thickness
- lends itself to UV / EB curing

Watch-Outs

- suitable for flat work only
- may require clean room
- foaming and curtain breaks are sometimes associated with waterborne coatings

References: 6, 28, 36

Opportunity 14

Use of Roll Coating

In roll coating, coatings are applied by rollers to a flat surface of the piece. The rollcoaters that apply the coating are often times engraved so as to produce a wood grain effect onto the piece if fiberboard or plywood.

Benefits

- high transfer efficiency
- reduced material waste
- high production rates
- allows the use of high solids coatings
- lends itself to UV / EB curing

Watch-Outs

- limited to flat work
- for solvent-based coatings, potentially large amounts of VOC emissions as the rollers have to stay wet
- will not coat cavities or hard to reach areas
- "ribs" resulting from poor flow of the coating are sometimes created on the substrate

References: 6, 28

Case Study
Steelcase, Inc.
Fletcher, NC

Steelcase installed a flatline roller coating system in 1985 in order to increase productivity, maintain consistent high quality, and reduce VOC emissions.

Paint was saved through an increased transfer efficiency and by converting to a high solids paint. A 30% - 50% decrease in rejects and associated touch-up work was achieved, and overall VOC emissions were reduced by 25%.

References: 18

Cleaning / Stripping

Opportunity 15

Alternatives to Methylene Chloride Strippers

Methylene chloride, the active ingredient in many coating strippers, has come under increasing scrutiny for its potential damage to health and the environment. Alternative stripping materials have been developed that have less potential for damage. These materials utilize the active ingredients:

- N - methyl pyrrolidone (NMP), a water soluble, biodegradable solvent that has relatively low toxicity, is nonflammable and noncarcinogenic, and
- Gamma - Butyrolactone, a water soluble, biodegradable solvent that is FDA approved and has tested noncarcinogenic in rats and mice.

Benefits

- biodegradable
- nonflammable
- no offensive vapors
- soap and water cleanup
- less VOC emissions

Watch-Outs

- hazardous waste may still be generated when using non-hazardous strippers because of the characteristics of the materials being stripped

References: 16

Operation and Maintenance

Please note that under the Clean Air Act, Work Practices Standards have been develped in the Draft Control Technique Guidelines for Wood Furniture . A copy of these standards is found in the Resources section of this Workbook, and should be used in conjunction with these recommendations.

Training of Operators

Formal operator training should include:

- communication of safety and health, quality, productivity, waste reduction and energy conservation goals and expectations, and how this will help the company and them as employees
- use of equipment in accordance with the manufacturer's specifications such as utilizing proper spray gun air or fluid pressures, coating concentrations and flow rates, care and maintenance
- proper spray technique fundamentals such as -
  - 50% overlap of the spray pattern
  - spray gun held 6 - 8 inches away from the workpiece
  - holding the spray gun perpendicular to the workpiece surface
  - triggering the gun at the beginning and ending of each pass
  - maintaining a consistent gun speed (general rule approximately 250 fpm)
- safety and health hazards associated with the equipment and materials and how to protect themselves, prevent accidents and environmental incidents

Some companies periodically videotape their operators so that the operators can critique themselves and point out where improvements are necessary (see the Case Study below).

Benefits

When finishing operators are properly trained, they can -

- reduce material costs
- achieve a higher quality finish
- reduce wastes and VOC emissions
- improve productivity
- improve workplace safety
- reduce incidence of injury (e.g., carpal tunnel syndrome) through ergonomic improvements

Watch-Outs

- informal training by other operators can continue bad habits
- infrequent training, or training inappropriate for the equipment or the coating type will not help

References: 18, 36

Case Study
Ethan Allen Furniture
Old Fort, NC

Ethan Allen has a training program for spray operators that utilizes video tapes as a training medium. The training consists of three stages:

1 - Operators are video taped while performing their job. It is important to positively communicate up front with the operators before the video taping starts so that there are no surprises.

2 - The operators in groups of three along with their supervisors and technical personnel, review the tapes in one hour sessions in order to identify ways to improve. Instruction on spray techniques is provided during the session and follow-up is provided during production on the manufacturing floor.

3 - The operators are taped again and given a chance to compare the tapes and observe the improvements.

The training is conducted twice a year and equipment and coating suppliers provide technical assistance. The company projects saving $ 50,000 to $ 70,000 annually as a result of 8 - 10% savings in material usage. Wastes and VOC emissions are also reduced.

References: 18, 37

Prepare Coatings Properly

Proper coating material preparation can impact the amounts of material used and wasted. Too much thinning or reduction can cause running and sagging, while too little reduction can cause defects such as orange peeling. These defects can result in rejects and waste.

Proper coatings preparation includes:

- always adding reducer to the material versus material to the reducer
- add reducer to the material slowly and test often to determine when you have reached the desired mixture
- test for complete mixing by sampling the top and the bottom layers of the mixture and placing each on separate pieces of glass to observe and compare color and rate of flow
- mix materials thoroughly before use and during use to maintain the desired uniformity
- keep tanks covered to prevent evaporative losses and contamination of the contents
- for continuous coating systems, monitor the viscosity of the coating in the reservoir so that the amount of solvent added is not excessive

References: 36

Direct Delivery of Coating to Spray Gun

Direct delivery of the coating material to the spray gun or application device instead of indirect transfer (e.g., filling an interim container from a drum or tank, transporting the container to the work area, transferring the coating material from the interim container to the spray gun or application device reservoir) can provide benefits and savings. There are three types of direct transfer systems:

1. Dead-end - supplies materials that do not have settling problems to the application with no return line

2. Simple flow - provides continuous circulation back to the storage tank through a return line which prevents settling in the storage tank

3. Fully recirculating - circulates the material throughout the system, including in the hose of the spray gun, to prevent settling of materials with high settling rates. This is especially useful when using preheaters with high solid coatings in order to maintain viscosity level.

Benefits

- volume cost discounts for bulk coating purchases
- less waste from spills during transfer, container residues, and evaporative losses
- less employee exposure to hazardous chemicals
- better finish quality through material consistency
- increased productivity and lower labor costs because of reduced transfer tasks
- lower solvent cost and reduced solvent wastes because interim containers do not need to be cleaned

References: 36

Opportunity 19

Use Heat to Obtain Desired Coating Viscosity

Traditionally, viscosity adjustments to coatings have been made by adding organic solvents as a reducer to the coating material. Also, as the ambient temperature of the work place changes, the viscosity of the coating being applied changes, which causes operator problems and gun adjustments. Heat, instead of solvent, can be used in some cases to adjust and maintain the incoming coating to the desired viscosity.

Benefits

- less solvent usage
- less waste solvent and VOC emissions
- more consistent viscosities
- faster curing
- allows the use of higher solids coatings
- improves coating flow and finish appearance

References: 18, 36

Caring for Spray Equipment

Regular care and maintenance must be performed on all equipment, especially spray equipment, to keep it in optimum working condition, prevent breakdowns or malfunctions, and waste. Some fundamental measures include:

- keep feed tanks clean of contamination such as dirt, dried coating particles, and dust, by keeping them covered whenever possible
- keep tanks agitated to prevent skim from forming and solids from settling
- locate the compressor where it can intake clean air and maintain it properly by checking filters and draining condensate
- select the appropriate spray gun attachments - needle, nozzle, air cap - for each coating utilized
- maintain proper fluid and air pressures
- correlate air pressure at the spray gun with the air pressure of the coating tank to maintain proper air pressure
- perform solvent pump maintenance to prevent leakage
- prevent spray gun leakage by placing only the front end of the gun in solvent when cleaning, lubricate bearings and packings of the spray gun daily
- do not spray lacquer and varnish in the same booth as it may cause spontaneous combustion
- whenever possible, do not spray different types of coatings in the same booth as it may make the resulting wastes mixed and more difficult and costly to dispose of or recycle
- use closed paint gun cleaning units to control VOC emissions and exposure
- equipment should be cleaned as soon as possible after use before coating cures and is more difficult to remove

References: 18, 35, 36

Equipment Cleaning

Finishing equipment cleaning is usually needed when a process is completed, for changes in coating materials or colors, and when maintenance is required. The more cleaning that takes place, the more waste that is usually generated. Also, solvents are often used to clean equipment and lines, generating waste solvents and VOC emissions.

Here are some ideas that can help you reduce waste from equipment cleaning:

- determine if cleaning is really needed, you may find that it is not
- minimize the number of cleanings of the equipment by finishing with a light coating first, then progressively use darker coatings whenever possible
- flush equipment first with dirty solvent, then with clean solvent
- use clean solvent as final equipment cleaning, then use as paint thinner
- use high velocities instead of high volumes of solvent cleaners
- centralize solvent cleaning operations to reduce losses and standardize cleaning methods and type of solvent used
- use mechanical cleaning such as scraping and wiping instead of solvent soaking / rinsing
- utilize teflon lined tanks to improve drainage and minimize waste coating build-up on tank walls
- use rubber wipers to remove coatings off tank walls instead of rags
- use other less hazardous or environmentally damaging solvents
- use air to blow lines free of coating back to pots

References: 35, 36

Case Study
Ethan Allen Furniture
Old Fort, NC

1. Cardboard filters that were used for all coating operations were replaced with metal filters. The cardboard filters were disposed of as waste, while the metal filters are cleaned in a solvent tank. The waste solvent / coating mix is distilled and the overspray is drummed for disposal, while the solvent is reused. The metal filters used for lacquer and sealer overspray are wiped by hand and the dust is sent off-site for recycling.

Cost: $ 57,000, Waste Reduction: 10,000 lbs. per year, Savings: $ 48,125.

2. A fabricated, sloped polyethylene trough replaced absorbant and wood shavings to catch coating overspray. The overspray is squeegeed from the trough into a pan and only the overspray is drummed for disposal.

Cost: $ 400, Waste Reduction: 6100 lbs. per year, Savings: $ 38,430.

3. Polyethylene covers replaced cardboard covers for the pallets that transferred products through coating operations. The overspray is peeled off the pallet cover and drummed for disposal.

Cost: $ 2050, Waste Reduction: 3700 lbs. per year, Savings: $ 7450

4. Racks used to transport product are now cleaned of overspray periodically by the boiler watchman during his free time. The racks can be reused instead of disposed as hazardous waste.

Cost: $ 200, Waste Reduction: 1900 lbs. per year, Savings: $ 8250.

References: 25

Inventory Management

Too much inventory or lack of inventory control for finishing materials can result in waste in the form of material never used (inventoried more than needed) or material that deteriorates before use (exceedance of shelf life). Work with material suppliers closely to provide just-in-time (JIT) material delivery and order accurate amounts needed for the job.

Benefits

- prevents costs for unneeded materials
- prevents waste disposal costs
- increased floor space
- less hazardous material stored

If you end up with an excess of material:

- return unused materials to the vendor (make arrangements with the vendor up-front before purchase)
- trade or give to other finishers to use
- contact a waste exchange to see if someone might be able to use the material

References: 36

Recycling of Finishing Materials

There are many opportunities for the recycling of finishing materials. Recycling reduces the amount of waste to be treated and disposed of, and the associated disposal and compliance costs. It also reduces the amount of new materials needed.

Some ideas for recycling include:

- distillation of solvents, either on site or off site
- extending solvent life by settling, filtration of solids, and using for jobs not requiring virgin solvent (e.g., rough cleaning)
- capturing overspray in the spray booth washwater and returning both the coating material and the washwater back to the process. Coating material that is immiscible in water can be separated from the booth waterwall by settling and ultrafiltration
- reusing clean-up solvents or solvent distillation sludge for coating secondary surfaces, where appearance is not a factor
- exchanging wastes with other companies or organizations

Watch-Outs

- make sure all environmental regulations are met when treating (e.g., distillation, incineration, etc.) solvents, especially chlorinated solvents

References: 36

Case Study
Boling Company
Mt. Olive, NC

Until January 1993, Boling was burning spent solvents from the finishing process for fuel. Boling installed a "Little Still" to recycle spent lacquer thinners from the plant's washoff operations. Even though the quality of the solvent product from the distillation process was not the quality necessary for reuse as washoff, by mixing one part acetone with three parts reclaimed solvent, the mixture could be used as a thinner in the spray coat operation. The stills operated four times a week and generates 40 - 60 gallons per week. Still bottoms are burned in the wood-chip fueled boiler for heat recovery.

The cost of the still was $ 4825, and operating costs are about $ 0.12 per gallon of solvent reclaimed. The net savings is about $ 100 per week, not including reduced waste disposal costs. The still paid for itself in one year.

References: 18, 36

Case Study
Medallion Kitchens
Waconia, MN

Medallion Kitchens manufactures kitchen cabinets and bathroom vanities. The company's desire was to reduce raw material costs, reduce VOC emissions, minimize hazardous waste disposal costs and associated liabilities, and decrease labor costs. Overspray from sealer and topcoat applications was a problem. About 75 gallons of sealer was used per day and 50 gallons of hazardous waste sludge was generated per day.

The company invested in a reclamation system for sealer overspray. The system consists of two holding reservoirs and some minor plumbing. The system is designed to catch most of the overspray before it falls into the washwater tank. A cooling water system is applied to the collection trays to minimize solvent evaporation, collected material is agitated to prevent "skinning", the reclamation trays are removed and replaced easily, and a non-stick coating is applied to the collection trays. After about 5 gallons of overspray is collected, the overspray is removed and solvent and catalyst is added to the material to obtain the desired coating properties. It is then added back to the spray system to be reused.

The system cost about $ 2500 per installed booth. Savings include $ 23,000 annually from reduced material usage. Waste sludge has been reduced from 50 to 25 gallons per day, saving the company $ 30,000.

References: 36

Case Study
Ethan Allen Furniture
Old Fort, NC

A solvent distillation unit was installed to recover solvents and reduce hazardous waste generation. A seven gallon batch still, which is run twice daily, recovers 5 gallons of reusable solvent for every 7 gallons of cleanup waste.

Cost: $ 4500, Waste Reduction: 1900 lbs. per year, Savings: $ 3200 per year

References: 25

Case Study
Sherman-Williams
Greensboro, NC

Sherman-Williams manufactures industrial coating materials. Waste from batch cleanup is separated by color and is then used as a feedstock when the next batch of the color is made. Waste mineral spirits have been reduced by 98% from 25,000 lbs. per year to 400 lbs. per year. Material purchases have also been reduced.

References: 37

Case Study
Thomson Crown Wood Products
Mocksville, NC

Thomson Crown previously disposed of its wet spray booth wastewater as hazardous waste. The company started a system to separate paint solid from the washwater and recycle the water back to the spray booth. The change reduced hazardous waste disposal costs by $ 92,500 and made the company the recipient of the Governors Award for Excellence in Hazardous Waste Management.

References: 37

Case Study
Lenoir Mirror Company
Lenoir, NC

Lenoir has installed a distillation system to distill xylene wastes. Off-site distillation had not proven satisfactory because the quality of the returned solvent was not as desired. After several attempts to find a reasonably priced still, Lenoir selected Finish Engineering's "Little Still". The still produces clean, usable solvent with a fifteen gallon per day capacity. Lenoir claims a 95% recovery rate of spent solvent, savings of $ 20 per day, and a thirteen month payback on the still.

References: 18

Case Study
Burlington Furniture Division
Lexington, NC

Burlington Furniture installed an in house incinerator to burn their spent solvents for heat recovery. The heat from the incinerator fires a boiler to make steam which is used to wash and dry rags. During the winter, excess heat is used to supplement the plant's space heat.

The cost of the incinerator in 1982 was $ 1.5 million. A three year payback was estimated. The incinerator burns 4000 gallons per year of spent solvent.

References: 18

Case Study
HiStrand Chemicals
Lenoir, NC

HiStrand offers users of conventional nitrocellulose lacquers a process called "ReLacs" that recycles lacquer dust into sealers and coatings for backs and drawers. HiStrand provides users with a step by step method emphasizing purity and safety. The only expenditure is for an air powered 10 mesh screen (sifter) which costs $ 1500. ReLacs users have recovered the cost of the sifter in about two weeks. Experience has shown that savings range from $ 700 to $ 3000 per month at each plant.

References: 29

5 Packing, Shipping and Warehouse

Process Description

Packing operations typically includes the following:

- attaching hardware or inserting for customer attaching
- securing drawers for shipment to prevent damage
- placing the mirror in mirror frames to prevent breakage
- general cleanup
- final inspection
- touch-up, if needed
- packing and labeling to provide the necessary protection to prevent damage during shipping

Shipping and warehouse activities include finished product inventory control and material handling operations to move furniture inventory. Material handling equipment such as forklifts, overhead conveyors, and in-floor chain conveyors are commonly used.

Packing, Shipping, and Warehouse Wastes

- paper
- wood waste (pallets, packaging)
- packing materials
- broken mirrors, glass
- damaged hardware

Opportunity Summary

The following are opportunities for waste reduction in Packing, Shipping and Warehouse. Summaries of these opportunities follow.

1. Enhance Packaging Performance by Evaluating Damage History (thus reducing product damage and waste)

2. Enhance Packing Performance by Evaluating Packaging Water Resistance

3. Decrease Toxic Metals Content of Packaging Materials

4. Eliminate Ozone Depleting Substances in Packaging Materials

5. Redesign Packaging to Minimize Volume and Weight - by Evaluating Packaging Materials and Closure Methods

6. Develop Reusable Containers

7. Improve Compatibility of Packaging Materials for Recycle.

8. Recycle Other Wastes Produced in the Packaging, Shipping and Warehouse

Opportunities

Opportunity 1

Enhance Packaging Performance by Evaluating Damage History

It is clearly understood that management of packaging material for furniture products is a major source of environmental concern due to the large volume of material used for protection of the furniture. However, it is also understood that inadequate packaging can result in furniture being damaged in transit and subsequently disposed in some cases, thereby creating a larger environmental problem than the packaging.

The opportunity presented here is to minimize the damaged furniture waste by improving packaging. Records should be collected of what goods are damaged. Evaluate these records periodically to determine sources of packaging problems. What caused the piece of furniture to be damaged? Would additional labeling aid in the situation? Would a different packaging approach provide protection from such incidents? Develop methods of improving packaging to eliminate or minimize these problems.

As an example, staples which have not been completely removed from a box before the furniture is removed, have been known to produce significant scratches on a new product (and in some case, on the customer, resulting in lawsuits). Changing to tape, banding or hot melt adhesives for box closure eliminates this source of damage.

Evaluate current and proposed packaging practices according to standard methods for packaging assessment. "ASTM D4169-93 Standard Practice for Performance Testing of Shipping Containers and Systems" provides testing procedures for evaluating the ability of packaging to adequately protect the contents during distribution. By using test methods to evaluate the packaging, it will be possible to improve packaging efficiency without having to incur actual product damage.

Packaging systems can be improved by evaluating the sources of past furniture damage, and conducting performance tests on current and proposed packaging. Bad damage to a large piece of furniture has an environmental price as well as a financial price related to the wasted production of the piece and the ultimate disposal of the piece.

References: 1

Opportunity 2

Enhance Packing Performance by Evaluating Packaging Water Resistance

Furniture pieces are typically sensitive to water damage, therefore, most packages must be carefully protected from exposure to water. Unfortunately, there are many cases where boxes are exposed to blowing rain or snow at loading docks, leaks in trailers and extremely high humidity. In these cases, it is important that the basic packaging materials be water resistant.

Various test methods exist for evaluating the water resistance of packaging materials. The Technical Association of Pulp and Paper Industries (TAPPI) developed test methods including the "Cobb Test" for evaluating water adsorptiveness of sized paper and Paperboard (TAPPI Test Method T 441 om-84, 1984). The ASTM Committee D-10 on packaging has developed standards for water resistance for box closure adhesives and tapes. In a recent study (Sheehan), the ASTM water resistance tests were used in conjunction with the ASTM package performance tests (referenced in Opportunity 1; ASTM D 4169-93; Standard Practices for Performance Testing of Shipping Containers and Systems) to test different types of closures. The water resistant film tape maintained package integrity while the paper reinforced tape without water resistant adhesive failed in the ASTM performance drop test.

When selecting packaging materials, ask suppliers how the materials ranked in standardized water resistance tests and choose materials which have sufficient water resistance and strength to properly protect the furniture being shipped.

References: 1, 2, 10, 32, 34

Opportunity 3

Decrease Toxic Metals Content of Packaging Materials

Packaging materials will either be reused, recycled or disposed (typically by landfill or incineration). In cases of recycle or disposal, it is important to decrease or eliminate the toxic content of the packaging materials. Inks for printing messages on the boxes and on labels have typically been the most significant source of toxic contamination for packaging materials.

The CONEG "Model Toxics Legislation" addresses the problem of toxics in packaging materials. The model legislation proposes the establishment of stringent specifications restricting the amount of certain toxics used in packaging or packaging components (inks, dyes, pigments, and adhesives). The legislation requires that manufacturers of packaging and packaging components certify that no lead, cadmium, mercury or hexavalent chromium have been intentionally added to the product. Further the manufacturers must certify that the sum of the incidental levels of lead, cadmium, mercury and hexavalent chromium does not exceed:

1. parts per million on January 1, 1992 (or the second anniversary date of the legislation in the particular state)
2. parts per million by January 1, 1993 (or the third anniversary date;
3. parts per million by January 1, 1994 (or the fourth anniversary date); and
4. A six year exemption is allowed for packaging which exceeds these limits if the exceedance is due only to the presence of metals in recycled materials used to make the package.

This law has been passed in 17 states and is being considered in at least 3 more states. Compliance dates may vary from state to state.

Where packaging materials will be shipped into states that have passed toxics legislation, it is critical that the furniture manufacturer obtain certification of compliance with the toxics legislation from the packaging manufacturer. Additionally, where waste reduction opportunities include recycling of packaging materials, it is important to be sure that materials to be used in the recycling process will not cause the final product to exceed the CONEG toxic legislation limits.

References: 22, 23, 26, 30

Opportunity 4

Eliminate Ozone Depleting Substances in Packaging Materials

The Clean Air Act Amendments of 1990 require the labeling of containers of substances categorized as Class I or Class II ozone depleting substances. Products containing Class I substances and products manufactured with Class I substances (including packaging materials and furniture) must also be labeled. This requirement applies to all products manufactured after May 15, 1993.

It is necessary to evaluate all packaging materials and obtain certification from the packaging manufacturers that there are no ODSs contained in or used in the manufacture of the materials. (This should be done for all suppliers of materials used in the furniture production process as well as the packaging process.) Products and packages should carry a "CFC-free" label to assure the customers that this issue has been properly addressed.

References: 27

Opportunity 5

Minimize Volume and Weight of Packaging Materials

Although it is ultimately important to protect the product, it is also desirable to minimize the packaging required to the extent possible. As described in the "Preferred Packaging Guidelines" issued by CONEG, note that although "no packaging" is the ideal alternative, minimizing packaging is the second alternative (above reuse and recycle). By decreasing the packaging required, the manufacturer is saving on five fronts:

- Less raw materials are required to produce the packaging
- Less labor is required to package the material (in many cases)
- Less energy is needed to transport the package
- More efficient package size is achieved (decreasing cost of transport)
- Less waste requires handling (whether reuse, recycle or disposal) at the end point

Selection of packaging materials should include evaluation of the total energy and other environmental resources used to create the packaging, as well as the energy required to ship the package. Various materials are being developed for packaging which are lighter weight yet equally strong.

Some special self sticking stretchable film tapes are being used in the place of considerable quantities of shrink wrap for specific applications. These tapes are reducing the volume and weight of packaging materials used and are recyclable.

Wood is also often used in packaging. As an example, wooden skids are often used under a piece of furniture to transport the piece around the manufacturing facility, and later to support that piece in the shipping container. Heavy duty cardboard skids have been developed that sufficiently carry the furniture load, protect the furniture in transit and can be recycled. Wooden skids are more expensive to purchase and are much heavier than cardboard, adding to the fuel charge for shipping. In one case study (presented later in this chapter), a facility was able to significantly decrease materials and shipping costs by simply changing to the cardboard skids from the wooden skids. Wooden skids are also more difficult for the customer to recycle than cardboard. In many locations, cardboard is picked up by municipal collection crews, while wooden skids are not.

Minimize Volume and Weight of Packaging Materials (continued)

An alternative to conventional plastic, paper and wood is the development of bioplastics; plastics created from fermentation of glucose by natural bacteria. The bioplastics can be processed and used in the same manner as other plastics. One advantage of bioplastics is that they can be produced from a renewable resource (typically corn) and are biodegradable when exposed to aerobic conditions and microbial activity (for example in a composting system). However, the cost of producing bioplastics is about 10 times the cost of producing conventional plastics.

The decision on whether to use paper, plastics or bioplastics is complex and confusing and must be addressed on a case by case basis. The best advice is to use as little of whatever type of packaging is chosen and reuse or recycle as much as possible. Minimizing the overall weight of the package (as well as the volume) will also result in savings on energy resources needed to transport the package.

Although in relative terms, the closure tape or glue is a small component of the package as a whole, all components of a package should be considered. Performance, weight and impact on the recycling of the primary packaging should be considered when looking at closure methods.

For box closures and plastic wrapped materials, polypropylene pressure sensitive tape has been developed which is more reliable and much lighter than reinforced gummed paper tape, hot melt adhesives, staples or non-metallic banding. Table 5-1 below shows a comparison of the weight of different box closure methods for closure of an 18x12x12-inch corrugated container containing 30 lbs of goods and subjected to moderate shipping and handling conditions (Jensen).

Choose light weight, reliable, and reusable (or recyclable) primary materials and choose closure methods which are also light, reliable and compatible with the reuse or recycle of the primary materials (See discussion of compatibility Opportunity 7).

References: 12, 13, 15, 38

Table 5-1
Weight and Mass of Box Closure Methods

Material	Weight (oz)	Mass (g)
Polypropylene PSA Box Sealing Tape (2-inch 3M #373)	0.1	3
Staples	0.3	9
Hot Melt Adhesive (applied to box flaps)	0.2	6
Non-Metallic Strapping	0.3	9
Reinforced Gummed Tape (3-inch fiberglass reinforced paper)	0.4	12

Case Study

Replace Wooden Skids with Heavy Duty Cardboard Skids

As mentioned in Opportunity 5, a wooden skid is often used under a piece of furniture to transport the piece around the manufacturing facility, and later to support that piece in the shipping container. Switching from wooden skids to heavy duty cardboard skids created significant savings in materials and shipping for the facility in this case study. Table 5-3 below provides a summary of the cost savings realized by the facility.

Table 5-3.
Cost Savings For Using Cardboard Skids Instead of Wood Skids

1.	How Many Cases Per Day	500
2.	Days Worked Per Year	250
3.	Total Cases Per Year (Item 1 x Item 2)	125,000
4.	Weight of Wood Skid (lbs)	11
5.	Weight of Cardboard Skid (lbs)	2
6.	Difference in Weight (lbs); (Item 4 - Item 5)	9
7.	Lbs. Saved Per Year; (Item 6 x Item 3)	1,125,000
8.	Cost to Ship Per Lb.	$ .08
9.	Freight Savings $'s Per Year (Item 7 x Item 8)	$90,000
10.	Material Cost of Wood Skid	$ 1.00
11.	Material Cost of Cardboard Skid	$ .56
12.	Cost Difference (Item 10 - Item 11)	$ .44
13.	Savings Per Year (Item 3 x Item 12)	$55,000
14.	**Total Savings Per Year** (Item 9 + Item 13)	**$145,000**

References: 33

Opportunity 6

Develop Reusable Containers

Concern with packaging has resulted in an interest in developing reusable containers. This interest has been addressed on an international basis as well in the United States. In Germany, a packaging ordinance was passed in June 1991 which obligates manufacturers and suppliers to reclaim used shipping containers and to either reuse them or to transmit them for recycling rather than sending them to conventional disposal facilities. Similar standards have been developed in other European countries and more recently in areas of in the United States.

When selecting packaging for furniture delivery, reuse and recycling goals established by state legislation should be considered. It is best if manufacturers develop containers which can be returned to the manufacturing facility to be reused. Cardboard boxes, if taped not stapled or hot melt glued, can be effectively slit, collapsed and returned in quantity to the manufacturer from a retailer. Bins could be used for reusable corner protection blocks and other support items. These bins could be filled at the retailer's facility then returned to the manufacturing plant when full. A credit or some other incentive could be associated with return of packaging materials to the manufacturer where reuse of these materials will result in an economic savings to the manufacturer. In many cases, reusable protective blankets are used to protect furniture in transit to the retailer or customer.

In cases where distribution is handled by the furniture company's own fleet of trucks, the boxes and other packaging materials can be returned on the empty truck after it delivers a load to the retailer. The truck has to return to the plant anyway.

In cases where the packaging will go all the way home with the customer, the response is not quite as simple. If the retailer delivers the item, the truck can bring back the packaging materials. If not, the consumer must deal with the packaging. In many cases, cardboard will be taken to a recycling center which is a better option than disposal, but not as desirable an option as reuse of the materials.

Some furniture companies are developing packaging bags which can be collapsed and mailed back to the manufacturer. In these cases, the customer may be provided with a large sturdy envelope or small box in which to put all the packaging material. The envelope or box could be pre-addressed to the manufacturer and have a return postage paid guarantee to encourage customers to use the system. The practicality of this approach must be determined on a case by case basis, but should be considered in packaging selection.

References: 14

Opportunity 7

Improve Compatibility of Packaging Materials for Recycle.

In many cases a reuse system may not be able to be established. Even where such a system is in place, the recyclability of packaging materials which are either damaged beyond continued use or escape the reuse circle should be considered. The two major types of recyclable packaging materials currently used in furniture packaging are plastic (polyethylene or other plastic) wrapping film and corrugated cardboard. Additionally, wood, metal and some foam products are used in the packaging process.

The recyclability of the packaging material should be considered on the basis of technical opportunities and practical options. It may be technically possible to recycle the material, but it is also necessary to have the collection systems in place for the retailer and the customer to use to get the materials to the right recycling facility. For some plastics, collection systems are not available in some towns, leaving plastics out of the recycling loop. In most areas, cardboard, glass, aluminum and steel recycling collection systems are available.

Following the choice of the primary packaging material, it is necessary to evaluate the method of closure. It is important that the materials used to tape or seal the package do not interfere with the recycling of the major packaging material in question.

Polyethylene wrapping film is recycled by melting and repouring for new use. Polypropylene tape is often used to bind wrapping film around an object. In tests where the tape accounted for up to 2 percent of the total weight of the packaging material and tape, the presence of the tape was not found to interfere with the recycling process. Higher percentages may be acceptable but have not been tested. (The specific construction of the tape is important. The recyclability referenced may not be true for all tapes.)

If recycle through melting and repouring is not feasible for some reason, the polyethylene wrapping can be burned for energy recovery. Where this is the case, the BTU value of the packaging material is augmented by the polypropylene tape.

Recycling of old corrugated cardboard (OCC) is highly dependant on the ability of the paper fibers to disperse in water.

Improve Compatibility of Packaging Materials for Recycle (continued)

Laminated and coated papers are not as amenable to recycling because it is difficult to get the materials into solution and the laminates and wax-coats contribute to the problems with "stickies" (globules of tacky material which may result in sticking of paper and possible flaws in the final paper). Some types of labels and closure materials are not amenable to recycling. Any tape adhesives and hot melt adhesives which pass through the cleaning process and stay in the slurry will turn into "stickies". The presence of stickies is a significant concern in quality control for recycling of paper.

According to a information from the US Forestry Service (Klungness), the three major sources of problems with "stickies" in the OCC recycling process are wax-coated corrugated cardboard, hot-melt adhesives and pressure sensitive labels where the adhesive is not designed to stay with the backing during the recycle process.

Tapes and labels which are designed to meet two specific criteria are preferable for use on packaging materials to be recycled. These criteria are:

a) the adhesive must stay with the backing when placed in a water slurry, and

b) the backing must remain intact during the recycling process so it can be easily removed with devices normally employed in the process.

In a study conducted by the Forest Service, pressure sensitive plastic tape designed to meet these requirements was found to not interfere with recycling and to not impact the quality of the paper product.

Staples are not considered a technical problem for the recycling process. However, in some areas of the country, staples have been a problem for recycling collection operations. Some recycling collection operations will not handle the stapled boxes. The justification given is that workers have a high rate of injury (cuts and scratches) from handling the stapled boxes. The health and safety aspects are a problem to the recycling companies so they often establish policies stating that they simply will not handle stapled boxes.

Table 5-2 provides a comparison of different types of closure methods with an indication of the impact on recyclability.

References: 7, 17, 31

Table 5-2
Comparison of Closure Method Impact on Recycling Operations

Closure Material	Recyclable	Removable in Recycle Process	Possible Paper Contaminant	Possible Water Contaminant
Staples		✓		
Plastic Pressure Sensitive Tape and Labels Components: Plastic Adhesive		 ✓ ✓ (stays on plastic)		
Paper Pressure Sensitive Tape and Labels Components: Paper Adhesive	 ✓		 ✓ (dissolves off paper)	
Reinforced Gummed Tape - Paper - Components: Paper Fiberglass Laminating Adhesive Gummed Adhesive	 ✓	 ✓	 ✓	 ✓
Strapping		✓		
Hot Melt Adhesive			✓	
Water Borne Adhesive				✓

References: 31

Recycle Other Wastes Produced in the Packaging, Shipping, and Warehouse

Recyclers are available for paper (paper, cardboard), wood (pallets, frames, skids), metals (hardware, fasteners), and glass. If the materials cannot be reused within the facility, check to see if it can be reused or recycled externally. Keep dedicated containers in work areas as receptacles for each type of material.

Case Study

Corrugated Re-use at Shelby Williams Industries, Inc.

Corrugated cardboard from cartons received with raw materials in addition to the dunnage wrapped around pallets of product cartons created large amounts of scrap for Shelby Williams Industries. Historically, the scrap was picked up by recyclers, however it was suggested that this material was appropriate for use as carton inserts and furniture edge protectors, which Shelby Williams was purchasing by the thousands each week.

In 1992, a small, in house department was established to re-cut the scrap cardboard into inserts. Machines were designed and developed by Shelby Williams employees to die cut and crease edge protectors and other inserts. Even though the project was successful, the remaining odd shaped scrap that remained after cutting was not acceptable by recyclers, and many smaller boxes did not convert to the insert sizes required. Shelby Williams had no boiler where scrap might be used as fuel.

To resolve this problem, Shelby Williams made arrangements with a local recycler to take all their scrap cardboard for no cost. The recycler then uses Shelby Williams "homemade" cutting and creasing machines to make all the inserts that Shelby Williams needs at no charge, or for only a few cents each to cover labor costs.

The net result is a reduction of the cost of inserts from an average of 22 cents each to about 3 cents each. Applied over 3000 to 5000 inserts per week, significant savings were realized. Also, most of the cardboard is re-used rather than recycled which prevents additional energy usage associated with recycling.

6 Building and Equipment Maintenance

Process Description

Building and equipment maintenance is necessary to keep the facility and equipment operating. This means a variety of tasks and the generation of a variety of wastes.

Typical tasks include:

- repairing and maintaining equipment - installing new parts, changing lubricating oils, cleaning equipment
- installing new equipment and removal of old equipment
- kiln and boiler operation and maintenance
- repairing and maintaining the facility and grounds - plumbing, electrical, carpentry, and landscaping tasks
- plus many other activities

Building and Equipment Maintenance Wastes

- lubricating oils
- scrap metal
- spent cleaning chemicals
- spills and spent absorbent materials
- boiler treatment chemicals
- boiler air emissions
- boiler ash
- cooling tower blowdown
- compressor condensate
- general trash

Opportunity Summary

The following are opportunities for waste reduction in Building and Equipment Maintenance. Summaries of these opportunities follow.

1. Use Synthetic Lubricating Oils with Longer Life
2. Recycle Oils
3. Maintain Kiln and Controls
4. Oil Clean Up with Recyclable Absorbents
5. Keep Chemical Wastes Segregated
6. Segregate and Recycle Paper, Wood, Metals and Glass
7. Use Wood Boiler Ash as a Soil Conditioner

Opportunities

Opportunity 1

Use Synthetic Lubricating Oils with Longer Life

Synthetic oils are available that can replace conventional oils and will lubricate better and last longer. Replace old oils with synthetic oils whenever possible. Be sure to check with the equipment manufacturer before making the change.

Opportunity 2

Recycle Oils

Oil purifiers that can recycle machine lubricating and hydraulic oils are available. Many of these are portable so that they can be rolled right to the machine that needs to be serviced. Also, oils can be taken to off-site recycling facilities.

Opportunity 3

Maintain Kiln and Controls

Heat and other energy that is used by the kiln can be lost if maintenance is not performed. The following areas need regular attention in a kiln preventive maintenance program:

- door seals
- baffles
- door seals
- kiln coating
- fan bearings
- line shaft stands
- fin pipe protection
- control calibration
- wet bulb socks
- V- belts and sheaves on fan drives

Opportunity 4

Oil Spill Clean Up with Recyclable Absorbents

Using organic based absorbents may allow their use in waste oil burners. Using sponges to pick up most of the liquid may allow oil reuse if not contaminated beyond usage specifications. Also, sponges can be wrung out and used again.

Opportunity 5

Keep Chemical Wastes Segregated

Many times chemical wastes are mixed because users believe they have no further use. Some spent chemicals can be recycled. Even if recycling is not an option, chemical mixing of a non-hazardous waste with a hazardous waste makes a greater volume of hazardous waste. The mixture must be managed as a hazardous waste and the disposal or treatment costs will be much higher.

Keep chemical wastes segregated and investigate recycling as an option. Do not mix unknown chemical wastes as the mixture may be reactive and cause a fire, explosion or spill. It also may be less expensive to dispose of two containers of segregated waste than one container of mixed wastes.

Opportunity 6

Segregate and Recycle Paper, Wood, Metals and Glass

Recyclers are available for paper (paper, cardboard, packing material), wood (pallets, frames, skids), metals (hardware, fasteners), and glass.

If it can't be recycled within your facility, check to see if it can be recycled externally. Keep marked, dedicated containers in work areas as a receptacle for each type of material.

Use Wood Boiler Ash as a Soil Conditioner

Wood ash has some positive properties as a soil conditioner / additive. Before applying this activity, check with your local solid waste regulator and farm agent, farm co-op, or agricultural college.

References

Assistance in obtaining the listed references can be provided by the

Waste Reduction Resource Center
3825 Barrett Drive, Suite 300
P. O. Box 27687
Raleigh, N. C. 27611-7687
Tel. 1 - 800 - 476 - 7687

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are information sources that can provide
additional information on the overall subject
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Waste Reduction Resources

Work Practice Standards
as written in the
Draft Control Technique Guidelines
for Wood Furniture Finishing

As referenced in Section 4 Finishing, Operation, and Maintenance sub-section.

B.5 WORK PRACTICE STANDARDS

(a) Work practice implementation plan

(1) Each owner or operator of an affected source subject to this rule shall prepare and maintain a written work practice implementation plan that defines environmentally desirable work practices for each wood furniture manufacturing operation and addresses each of the topics specified in paragraphs (b) through (j) of this section. The plan shall be developed no more than 60 days after the compliance date. The written work practice implementation plan shall be available for inspection by the Agency, upon request. If the Agency determines that the work practice implementation plan does not adequately address each one of the topics specified in paragraphs (b) through (j) of this section, the Agency may require the affected source to modify the plan.

(b) Operator training course. Each owner or operator of an affected source shall train all new and existing personnel, including contract personnel, who are involved in finishing or cleaning operations or implementation of the requirements of this rule. All personnel shall be given refresher training annually. The affected source shall maintain a copy of the training program with the work practice implementation plan. The training program shall include, at a minimum, the following:

(1) A list of all personnel by name and job description that are required to be trained;

(2) An outline of the subjects to be covered in the initial and refresher training for each person, or group of personnel;

(3) Lesson plans for courses to be given at the initial and the annual refresher training that include, at a minimum, appropriate application techniques, appropriate cleaning procedures, appropriate equipment setup, and adjustment to minimize finishing material usage and overspray, and appropriate management of cleanup wastes; and

(4) A description of the methods to be used at the completion of initial or refresher training to demonstrate and document successful coompletion.

(c) Leak inspection and maintenance plan. Each owner or operator of an affected source shall prepare and maintain with the work practice implementation plan a written leak inspection and maintenance plan that specifies:

(1) A minimum visual inspection frequency of once per month for all equipment used to transfer or apply finishing materials or organic solvents;

(2) An inspection schedule;

(3) Methods for documenting the date and results of each inspection and any repairs that were made;

(4) The timeframe between identifying a leak and making the repair, which adheres to the following schedule:

(*i*) A first attempt at repair (e.g., tightening of packing glands) shall be made no later than 5 working days after the leak is detected; and

(*ii*) Final repairs shall be made within 15 working days, unless the leaking equipment is to be replaced by a new purchase, in which case repairs shall be completed within 3 months.

(d) Cleaning solvent accounting system. Each owner or operator of an affected source shall develop an organic solvent accounting form to record:

(1) The quantity and type of organic solvent used each month for washoff and cleaning;

(2) The number of pieces washed off, and the reason for the washoff; and

(3) The quantity of spent organic solvent generated from each activity, and the quantity that is recycled onsite or disposed offsite each month; and

(e) Each owner or operator of an affected source shall not use organic solvent containing more than 8.0 percent of weight of VOC for cleaning spray booth components other than conveyors, continuous coaters and their enclosures, and/or metal refurbished, that is, the spray booth coating or other material used to cover the booth is being replaced, the affected source shall use no more than 1.0 gallon of organic solvent to clean the booth.

(f) Each owner or operator of an affected source shall use normally closed containers for storing finishing and cleaning materials.

(g) Each owner or operator of an affected source shall not use conventional air spray guns for applying finishing materials except under the following circumstances:

(1) To apply finishing materials that have a VOC content no greater than 1.0 kg VOC/kg solids (1.0 lb VOC/lb solids), as applied;

(2) For final touch-up and repair;

(3) If spray is automated, that is, the spray gun is aimed and triggered automatically, not manually;

(4) If emissions from the finishing application station are directed to a control device;

(5) The conventional air gun is used to apply finishing materials and the cumulative total usage of that finishing material is less than 5 percent of the total gallons of finishing material used during that semiannual reporting period; or

(6) The conventional air gun is used to apply stain on a part for which it is technically or economically infeasible to use any other spray application technology. The affected source shall demonstrate technical or economic infeasibility by submitting to the Agency a videotape, a technical report, or other documentation that supports the affected source’s claim of technical or economic infeasibility. The following criteria shall be used, either independently or in combination, to support the affected source’s claim of technical or economic infeasibility:

(*i*) The production speed is too high or the part shape is too complex for one operator to coat the part and the application station is not large enough to accommodate an additional operator; or

(*ii*) The excessively large vertical spray area of the part makes it difficult to avoid sagging or runs in the stain.

(h) Each owner or operator of an affected source shall pump or drain all organic solvent used for line cleaning into a normally closed container.

(i) Each owner or operator of an affected source shall collect all organic solvent used to clean spray guns into a normally closed container.

(j) Each owner or operator of an affected source shall control emissions from washoff operations by:

(1) Using normally closed tanks for washoff; and

(2) Minimizing dripping by tilting or rotating the part to drain as much organic solvent as possible.

Pollution Prevention
National Roundtable

Pollution Prevention National Roundtable

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South Carolina	Willie J. Morgan Dept. of Health & Env. Control, Bur. of Env. Quality Control 2600 Bull Street Columbia, SC 29201 803-734-5179 FAX 803-734-5199	Otto Pearson Dept. Health and Env. Control 2600 Bull Street Columbia, SC 29201 803-734-4750 FAX 803-734-4556	James Joy Bur. Air Qual. Ctrl. Dept. of Health and Env. Control 2600 Bull Street Columbia, SC 29201 803-734-4750 FAX 803-734-4556
South Dakota	Joe D. Nadenicek Small Bus. Ombudsman Dept. of Env. & Natural Resources Joe Foss Bldg. 523 East Capitol Pierre, SD 57501 605-773-3151 FAX 605-773-6035		Bryan Gustafson Dept. of Env. & Natural Resources Joe Foss Bldg. 523 East Capitol Pierre, SD 57501 605-773-3351 FAX 605-773-6035
Tennessee	Ernest Blankenship TN Dept. of Env. & Conservation L&C Tower 401 Church St. Nashville, TN 37243-0454 615-532-0734 FAX 615-532-0231	Linda Sadler Small Bus. Asst. Prog. 8th Floor, L&C Annex 401 Church Street Nashville, TN 37243 615-532-0779 FAX 615-532-0614	

State	OMBUDSMAN	SBAP	OTHER SBAP
Texas	Tamra Shae-Oatman Small Bus. Omb. TX NRCC 12124 Park 35 Circle, Austin TX 78753 512-239-1062 FAX 512-239-1065	Kerry Drake Dir. Small Bus. Tech. Assistance Prog. TX NRCC 12124 Park 35 Circle, Austin TX 78753 512-239-1112 FAX 512-239-1055	Santos Olivare TX NRCC Office of the State Small Bus. Ombudsman 12124 Park 35 Circle, Austin, TX 78753 512-239-1404 FAX 512-239-1055
Utah		Frances Bernards Utah Dept. of Env. Quality, Div. of Air Quality P.O. Box 144820 Salt Lake City, UT 84114-4820 801-536-4056 FAX 801-536-4099	Ron Reece Env. Engineer Utah Dept. of Env. Qualityt DiV. of Air Quality P.O. Box 144820 Salt Lake City, UT 84114-4820 801-536-4091 FAX 801-536-4099
Vermont		Richard Valentinetti APCD/ANR Building 3 South 103 South Main Street Waterbury, VT 05676 802-241-3840 FAX 802-241-2590	
Virginia	Elizabeth J. Moran Director, Office of Permits Assistance VA Dept. of Env. Quality P.O. Box 10009 Richmond, VA 23240 804-762-4430 FAX 804-762-4510	Richard Rasmussen Director, Small Bus. Assistance Program VA Dept. of Env. Quality P.O. Box 10009 Richmond, VA 23240 804-762-4394 FAX 804-762-4510	
Virgin Islands	Rhudel George Dir. Business Dev. Agency P.O. Box 6400 Charlotte Amalie, St. Thomas, VI 00804-6400 809-774-8784 x255 FAX 809-774-4390	Florettee Champagnie Univ. of V.I. Small Bus. Dev. Center 8000 Nisky Center Suite 202, 2nd Floor Charlotte Amalie, St. Thomas, VI 00802-5804 809-776-3206 FAX 809-775-3756	Benjamin Nazario VI Dept. of Planning & Natural Resources Div. of Env. Prot. Bldg. 111, Apt. 114 Watergut Homes Christiansted, St. Croix, VI 00820 809-773-0565 FAX 809-773-9310

State	OMBUDSMAN	SBAP	OTHER SBAP
Washington	Leighton Pratt Dept. of Ecology P.O. Box 47600 Olympia, WA 98504-7600 206-407-7018 FAX 206-407-6802	Jerry Jewett Dept. of Ecology Air Qual. Prog. P.O. Box 47600 Olympia, WA 98504-7600 206-407-6805 FAX 206-407-6802	Judy Schwieters or Bernard Brady Dept. of Ecology Air Quality Prog. P.O. Box 47600 Olympia, WA 98504-7712 206-407-6804 or 206-407-68Q3 FAX 206-407-6802
West Virginia		Fred Durham WV office of Air Qual. 1558 Wash. St. East Charleston, WV 25311 304-558-1217 FAX 304-558-1222	Joe Ciccarello WV Dev. Office 1115 VA Street East Charleston, WV 25301 304-558-2960 FAX 304-558-0127
Wisconsin	Dennis Leong Director, Permit Info. Center, Bus. Compliance & Advocacy, Dept. of Dev. 123 West Wash. St. Madison, WI 53703 608-266-9869 FAX 608-267-2829	Robert Baggot Dept. of Nat. Res. Bureau of Air Mgmt. AM/07 P.O. Box 7921 Madison, WI 53707-7921 608-267-3136 FAX 608-267-0560	Brenda Hagman WI DNR/BAM AM/07 P.O. Box 7921 Madison, WI 53707-7921 608-266-5883 FAX 608-267-0560
Wyoming		Charles Raffelson Dept. of Env. Quality Div. of Air Quality 122 W. 25th Street Cheyenne, WY 82002 307-777-7391 FAX 307-777-5616	Charles Collins Dept. of Env. Qual. Div. of Air Quality 122 W. 25th Street Cheyenne, WY 82002 307-777-7391 FAX 307-777-5616

Waste Exchange Listing

WASTE EXCHANGE LISTINGS

NATIONAL MATERIALS EXCHANGE NETWORK
PARTICIPANTS AS OF OCTOBER 11, 1993

WASHINGTON
National Materials Exchange Network (PME)
1522 N. Washington Street, Ste 202
Spokane, WA 99201-2454
1-800-858-6625 Moden Number

ALABAMA
Alabama Waste Materials Exchange
Linda Quinn (Alme)
404 Wilson Dam Avenue
Sheffield, AL 35660
205-383-5630
(AL)

ALBERTA
Alberta Waste Materials Exchange
Cindy Jensen (ABWE)
Bldg. #350
6815 8th Street, N.E.
Calgary, AB T2E 7H7
403-297-7505; FAX 403-297-4548

ALBERTA
Canadian Chemical Exchange
Phillipe La Roche (Cce)
P. O. Box 1135
Ste-Adele, AB JOR lLO
800-561-6511; FAX 514-229-5344

ARIZONA
Arizona Waste Exchange
Barrie Herr (AZWE)
4725 E. Sunrise Dr., Suite 215
Tucson, AZ 85718
602-299-7716; FAX 602-299-7716

BRITISH COLUMBIA Waste Exc.
Jill Gillette (BCWE
102 1525 W. 8th Avenue
Vancouver, BC V6J 1T5
604-731-7222; FAX 604 734-7223

CALIFORNIA
California Waste Exchange
Claudia Moore (CWE)
P. O. Box 806
Sacramento, CA 95812-0806
916-322-4742; FAX 916-327-4494
(CA Hazardous Waste)

CALIFORNIA
CALMAX
Joyce Mason (CALMAX)
909 12th Street, Suite 205
Sacramento, CA 95826
916-255-2369; FAX 916-255-2221
(CA Solid Waste)

COLORADO
Rocky Mountain MateriaIs Exc.
John Wright (RMME)
1445 Market Street
Denver, CO 80202
303-692-3009; FAX 303-534-3200
(CO)

ARKANSAS
Arkansas Indus. Dev. Council
Ed Davis
#1 Capitol Hill
Little Rock, AR 72201
501-682-1370

FLORIDA
Intercontinental Waste Exc.
Anne Sternberg (ICWE)
5200 Town Ctr. Cir., Ste. 303
Boca Raton, FL 33486
800-541-0400; FAX 407-393-6164
(FL)

HAWAII
Hawaii Materials Exchange
Jeff Stark (HIMEX)
P. O. Box 1048
Paia, HI 96779 l
808-579-9109; FAX 808-579-9109
(HI)

ILLINOIS
Industrial Materials Exc. Srv.
Diane Shockey (IMES)
P. O. Box 19276
Springfield, IL 62794-9276
217-782-0450; FAX 217-782-9142
(AR,IL,KY,MO,OK,WI)

INDIANA
Indiana Waste Exchange
Jim Britt (INWE)
P. O. Box 454
Carmel, IN 46032
317-574-6505; FAX 317-844-8765
(IN)

IOWA
Iowa Waste Reduction Center
By-pro. And Waste Search Svr.
Susan Salterberg (IWRC)
75 BRC-Unv. of Northern Iowa
Cedar Falls, IA 50614-0185
319-273-2079; FAX 319-273-2893
(IA)

LOUISIANA
Louisiana/Gulf Coast Exc.
Rita Czek (LAGC)
1419 CEBA
Baton Rouge, LA 70803
504-388-4594; FAX 504-388-4945
(LA)

MANITOBA
Manitoba Waste Exchange
Todd Lohvinenko (MBWE)
1812-330 Portage Avenue
Winnipeg, MB R3C OC4
204-942-7781; FAX 204-942-4207

MINNESOTA
B.A.R.T.E.R.
Jamie Anderson (Barter)
2512 Delaware St., SE
Minneapolis, MN 55414
612-627-6811
(MN)

MINNESOTA
Olmsted County Materials Exe.
Jack Stansfield (OCME)
Olmsted County Public Works
2122 Campus Dr., SE
Rochester, MN 55904
507-285-8231; FAX 507-287-2320

KANSAS
Ransas Materials Exc.
Russell Fallis, Jr. (KSME)
P. O. Box 152
Hutchinson, KS 67504-0152
316-662-0551; FAX 316-662-1413
(KS)

KENTUCKY
EY Dept. of Env. Protection
Charles Peters
18 Riley Road
Frankfort, KY 40601
502-564-6761

MINNESOTA
MN TECHNICAL ASSISTANCE PRO.
Helen Addy
1313 5th Street, Suite 307
Minneapolis, MN 55414
612-627-4555

MINNESOTA
SEMREX
Anne Morse (SENREX
171 W. 3rd Street
Winona, NN 55987
507-457-6460
(MN)

MISSISSIPPI
MISSTAP
Caroline Hill (MISSTAP)
P. O. Drawer CN
Mississippi State, MS 39762
601-325-8454; FAX 601-325-2482
(MS)

MISSOURI
MO Env. Improvement Authority
Thomas Welch
325 Jefferson Street
Jefferson City, MO 65101
314-751-4919

MONTANA
Montana Industrial Waste Exc.
Montana Chamber of Commerce
P. O. Box 1730
Helena, MT 59624
406-442-2405
(MT)

NEW HAMPSHIRE
New Hampshire Waste Exchange
Emily Hess (NHWE)
122 N. Main Street
Concord, NH 03301
603-224-5388
(NH)

NEW JERSEY
New Jersey Materials Exchange
Valiant Paper
Cary Cohen (NJME)
300 West Commercial Avenue
Moonachie, NJ 07074
800-676-2754; FAX 201-896-1021
(NJ)

NEW MEXICO
New Mexico Materials Exchange
Four Corners Recycling
Dwight Long (NMME)
P. O. Box 904
Farmington, NM 87499
505-325-2157; FAX 505-326-0015
(NM)

NEW YORK
Hudson Valley Materials Exc.
Jill Grouper (HVME)
P. O. Box 550, 1 Veterans
Drive
New Paltz, NY 12561
914-255-3749; FAX 914-255-4084

NEW YORK
Northeast Ind. Waste Exc. Inc.
Carrie Maus-Pugh (NIWE)
620 Erie Blvd. W., Suite 211
Syracuse, NY 13204
315-422-6572; FAX 315-422-4005
(CT,DC,DE,MA,ME,NY,NJ,OH,PA,RI
WV,ME)

OKLAHOMA
Oklahoma Waste Exchange Pro.
Fenton Rude
P. O. Box 53551
Oklahoma City, OK 73152
405-271-5338

ONTARIO
Ontario Waste Exchange
Mary Jane Henley (ONWE)
2395 Speakman Drive
Mississauga, ON L5K 1B3
416-822-4111; FAX 416-823-1446

ONTARIO
Canadian Waste Materials Exc.
Robert Laughlin (CWME)
2395 Speakman Drive
Mississauga, ON LSK 1B3
416-822-4111; FAX 416-823-1446

OREGON
Portland Chemical Consortium
Dr. Bruce Brown (PCC)
P. O. Box 751
Portland, OR 97207-0751
503-725-3811; FAX 503-725-3811

QUEBEC
Bourse Quebecoise des Matieres
Secondaires
Dr. Francois Lafortune (BQMS)
14 Place Du Comm., Bureau 350
Le-Des-Squeurs, Quebec H3E lT5
514-762-9012; FAX 5i4-873-6542

SOUTH CAROLINA
Doug Woodson (SCWE)
155 Wilton Hill Road
Columbia, SC 29212
803-755-3325; FAX 803-755-3833
(SC)

TEXAS
RENEW
Hope Castillo (Renew)
P. O. Box 13087
Austin, TX 78711-3087
512-463-7773; FAX 512-475-4599
(TX)

VERMONT
Vermont Bus. Materials Exc.
Connie Leach Bisson (VBMX)
P. O. Box 630
Montpelier, VT 05601
802-223-3441; FAX 802-223-2345
(VT)

WASHINGTON
IMEX
Bill Lawrence (IMEX)
506 2nd Avenue, Room 201
Seattle, WA 98104-2311
206-296-4899; FAX 206-296-3997
(AK,OR,WA)

WASHINGTON
Pacific Materials Exchange
Bob Smee (PME)
1522 N Washington St. Ste. 202
Spokane, WA 99201-2454
509 325-0551; FAX 509-325-2086
(ID,RS,NM,ND,NE,NV,SD,UT,WY,VA, TN,NC,GA)

WISCONSIN
Bureau of Solid Waste Mgmt.
Lynn Persson
P. O. Box 7921
Madison, WI 53707
608-267-3763

NON MEMBERS OF NATIONAL EXCHANGE NETWORK

FLORIDA
(SWIX)
Southern Waste Information Exchange Clearinghouse
P. O. Box 960
Tallahassee, FL 32302
904-644-5516
800-441-7949

NORTH CAROLINA
Southeast Waste Exchange
Maxie May
Urban Institute-UNC Charlotte
Charlotte, NC 28223
704-547-2307
704-547-3178 FAX

OHIO
WasteLink
140 Wooster Pike
Milford, OH 45150
513-248-0012
Cincinnati, OH Service Area
Fee For Service

Other Exchanges

CANADIAN WASTE MATERIALS EXCHANGE
2395 Speaknun Drive, Mississauga, Ontario, CANADA L5K IB3
(416) 822-4111 (ext. 265) FAX (416) 823-1446

INDUSTRIAL MATERIAL EXCHANGE SERVICE
P.O. Box 19276, #31, Springfield, lL 62794-9276
(217) 782-0450 FAX (217) 524-4959

INDUSTRIAL WASTE INFORMATION EXCHANGE
5 Commerce Street, Newark, NJ 07102
(201) 623-7070

MANITOBA WASTE EXCHANGE
1329 Niakwa Roat, Winnipeg, Manitoba, CANADA R2J 3T4
(204) 257-3891 FAX (512) 475-2215

NORTHEAST INDUSTRIAL WASTE EXCHANGE
90 Presidential Plaza, Suite 122, Syracuse, NY 13202
(315) 422-6572 FAX (315) 422-9051

RENEW
Texas Water Commission, P.O. 13O87, Austin, TX 78711-3087
(512) 463-7773 FAX (204) 475-2215

GREAT LAKES WASTE EXCHANGE
3250 Townsend NE
Grand Rapids, Ml 49504-2054
(616) 363-3262 FAX (616) 363-0058

SOUTHEAST WASTE EXCHANGE
Urban Institute, UNCC Station, Charlotte, NC 28223
(704) 547-2307 FAX: (704) 547-2767

SOUTHERN WASTE INFORMATION EXCHANGE
P.O. Box 960, Tallahassee, FL 32302
(800) 441-7949/(904) 644-5516 FAX: (904) 574-6704

Vendor Listings

This is not an exhaustive list of vendors. For additional vendors, check publications such as the Thomas Register. This listing is for information purposes only and does not constitute any endorsement by those who have produced, prepared or contributed to this document.

COATING SUPPLIES

Abilene Research & Development
P.O. Box 294
Hewlett, NY 11557
(516) 791-6943

Adhesive Coatings Co.
2755 Campus Dr, Suite 125
San Mateo, CA 94403

Aexcel Corp
7373 Production Drive
Mentor, OH 44061
(216) 974-3800
Richard Milhelm

Akzo-Reliance, Inc
1431 Progress Street
High Point, NC 2 7 2 61
(9l9) 841-5111
Gerry Currier

Ameron Corp
P.O. Box 192610
Little Rock, AR 72219
(501) 455-4500
Mike Harris

Amity Finishing Products
P.O Box 107
Sun Prairie, WI 53590
(608) 837-8484
George Cash

Aquaday International Ltd.
1315 S. Evergreen
Arlington Heights, IL 60005
(708) 956-8511

Avery Decorative Films Div
650 West 67th Place
Schererville, IN 46375
(219) 322-5030
Greg Emily

C. E. Bradley Labs
P.O. Box 811
Brattleboro, VT 05301
(802) 257-7971
Rasefeed Kanaan

Cardinal Industrial Finishes
1329 Potrero Ave.
South El Monte, CA 91733
(818) 444-9274
Sam Ortolono

Chemcraft Sadolin Int. Inc.
P.O. Box 669
Walkertown, NC 27051
Gary Marshall

Compliance Coatings Inc.
P.O. Box 12411
St Louis, MO 63132
(314) 429-1300

Crown Metro, Inc
P.O. Box 5857
Greenville, SC 29606
(803) 299-1331
Greg Sprole

Duckback Products Inc
2644 Hegan Lane
Chico, Ca 95927
(916) 343-3261

Fuller Company, H. B.
3200 Labore Road
Vadnais Heights, MN 55110
(612) 481-9558

Glidden Coatings & Resin
SCM Corp.
925 Euclid Avenue
Cleveland, Oh 44115
(216) 344-8000

Guardsman Chemicals, Inc
2147 Brevard Road
Highpoint, NC 27261
(919) 889-6344
Ron Tucker

Hood Products
P.O. Box 220
Tennent, NJ 07763
(908) 247-2177
Eric Rasner

Hydrocote Co
P.O. Box 140
Tennent, NJ 07763
(908) 247-4344

James B. Day & Co
Day Lane
Carpentersville, IL 60110
(708) 428-2650
Steven Plumley

Lawrence Mcfadden Co
7434 State Road
Philadelphia, PA 19136
(215) 624-6333
Peter Beck

Lilly Co
P.O. Box 2358
High Point, NC 27261
(919) 889-2157
William Dorris

PPG Industries
7601 Business Park Dr
Greensboro, NC 27409
(919) 668-3780
Andy Riedell

Pratt & Lambert
40 Sonwill Drive
Buffalo, NY 14225
(800) 888-1849

Pratt & Lambert
16116 E 13th St
Wichita, KS 67230
Wallace Steele

Radcure Inc
217 Freedman Dr
Port Washington, WI
Keith Clark

Reneer Films Corp
Old Hickory Road
Auburn, Pa 17922
(717) 366-1051
Wendy Steed

Sherwin-Williams Co
101 Prospect Ave
Cleveland, OR 44115
(216) 566-2902

Snyder Bros.
Aveon Street
Toccoa, GA 30577
(706)886-6811
Len Snyder

Spruance Southern, Inc
Old Hyway 52 South
Winston-Salem, NC 27107
(919) 764-0940
David King

Star Bronze Co.
P.O. Box 2206
Alliance, OH 44601
(216) 823-1550

UCB Radcure, Inc
3519 Westwood Farms Dr.
Louisville, KY
(502) 491-1885

US Cellulose
520 Parot
San Jose, CA
(408) 295-0104
Jennifer O'hara

United Gilsonite Labs
P.O. Box 70
Scrarton, PA 18501
(717) 344-1202

Vanex, Inc
1770 South Shawnee St
Vernon, IL 62864
(618) 244-1413

Valspar Corp.
1647 English Road
High Popint, NC 27262
(919) 887-4600
James Bohasson

Velco Inc (Woodtex)
3900 W 1st Ave
Eugene, OR 97402
(503) 342-5738

RESIN SUPPLIERS

Cargill
2301 Crosby Road
Wayzeta, MN S5391
Mr. Al Heitkamp

Ciba Geigy
3 Skyline *Drive*
Hawthorne NY 10532-2188
Mr. William Collins

Dow Chemical Company
2040 Willard H. Dow Center
Midland, MI 48674
Ms. Karen Krigbaum

Eastman Chemicals
Eastman Road
Kingsport, TN 37660
Mr. Jeff Powell

ICI Resins
1717 Rivermist Drive
Lilburn, GA 30247
Mr. Edward Elkins

Mobay Corporation
Mobay Road
Pittburgh, PA 15205-9741
Dr. Bernd H. Riberi

Mobil Oil Corporation
3225 Gallows Road
Fairfax, VA 22037
Mr. Bill Press

Reichhold Chemicals, Inc.
525-T North Broadway
White Plains, NY 10603
Mr. Jeffrey Dannerman

Rohm and Haas
Independence Mall West
Philadelphia, PA 19105
Mr. Nick Roman

Sanncor Industries
300 Whitney Street
Leominster, MA 01453
Mr. Henry Merken

FINISHING EQUIPMENT MANUFACTURERS AND VENDORS

Accuspray
26881 Cannon Road
Cleveland, OH 44146
(800) 321-5992

Air Power, Inc.
P.O. Box 41165
Raleigh, NC 27629
(919) 828-9174

American Machine Corp.
1683 Blake Ave.
Los Angeles, CA SO031
(213) 221-7070

Apollo Sprayers Int'l.
10200 Hemstead Highway
Houston, TX 77092
(713) 680-9558

Binks Manufacturing Company
5575 Spalding Drive
Norcross, GA 30092
(404) Z7-5600

Black Bros. Company
1315 Baker Road
High Point, NC 27263
(919) 431-9145

CAN-AM Engineered Products
30850 Industrial Road
Livonia, Ml 48150
(800) 229-7551

Deile Vedove USA
6031 Harris Technology Blvd.
Charlotte, NC 28269
(704) 5S38-0020

Derda, Inc.
1196 West Bertrand Road
Niles, Ml 49120
(616) 1583-6666

Devilbiss Company
300 Phillips Avenue
Toledo, OH 43692
(419) 891-2169

E & R Supply Company, Inc.
1095 Route 110, Unit E
Fermingdale, NY 11735
(516) 752-3510

European Woodworking Machinery
P.O. Box 550
Franklinton, NC 27525-0550
(919) 494-5197

Fuji Industrial Spray Equip.
65 Martin Ross Ave. #5
Toronto, CANADA
(416) 650-1430

Fusion UV Curing Systems
7600 Standish Place
Rockville, MD 20855
(301) 261-0300

Graco, Inc.
4050 Olson Memorial Parkway
Minneapolis, MN 55440
(800) 367-4023

High Point Pneumatics
Box 5802
High Point, NC 27262-5802
(919} 889-8416

Industrial Heating & Finishing
P.O. Box 129
Pelham, Al 35124
(205) 663-9595

Kremlin, Inc.
211 South Lombard
Addison, 1L 60101
(708) 495-0616

Nordson Corporation
555 Jackson Street
Amherst, OH 44001
(216) 988-9411

Paint-O-Matic
Box 1426
Willits, CA 65490
(707) 459-941 1

Quickwood, Inc.
675 Progress Center Ave. Sta. A
Lawrenceville, GA 30243
(404) 339-1633

Ransburg Gema
P.O. Box 88220
Indianapolis, IN 46208
(317) 298-5001

Speeflo Manufacturing Corp.
4631 Winfield Road
Houston. TX 77039
(713) 675-1600

Stiles Machinery
3965 44th Street Southeast
Grand Rapids, MI 49508
(616} 698-7500

Union Carbide Unicarb System
39 Old Ridgebury Rd.
Danbury, CT 06817
(203) 7962737

Wagner Spray Tech Corporation
1 770 Fernbrook Lane
Minneapolis, MN 55447
(6t2) 553-0759

ADD-ON CONTROL VENDORS

ABB Flakt Alpha
29333 Stephenson Hwy.
Madison Heights, MI 48071
Mr. Steven Blocki

Baron-Blakeslee
2003 North Janice Avenue
Melrose Park, IL 60160
Mr. Sherman McCrew

Calgon Carbon Corporation
P.O. Box 717
Pittsburgh, PA 15230-0717
Mr. Mark Weissert

Classic Air Systems .
P. O. Box 6130
Buffalo Shoals Road
Statesville, NC 28677
Mr. Chuck Campbell

Combustion Engineerlng
Andover Road, Box 372
Wellsville, NY 14895
Mr. Brian Cannon

CVM Corporation
402 Vandever Avenue
Wilmington, DE l9802
Ms Roxanne Pietro

DCI International
1229 Country Club Road
Indianapolis, IN 46234
Mr. Bob Zopf

Durr Industries
40600 Plymouth Road
Plymouth, MI 48170-4297
Mr. Pinesh Bhushan
.
George Koch Sons, Inc.
10 S. Eleventh Avenue
Evansville,. IN 47144
Mr. Don Miller

Global Environmental
P.O. Box 2945
Greenville, SC 29602
Mr. John Hatcher

Hirt Combustion Engineers
931 South Maple Avenue
Montebello, CA 90640
Mr. Chris Oakes

Hoyt Manufacturing Corp.
251-T Forge Road
Westport, MA 02790
Mr. Steven Rooney
.
Huntington Energy Systems
1081 Briston Road
Mountainside, NJ 07092
Mr. Ray Elsman

Industrial Technology Midwest
P.O. Box 626
Twin Lakes, WI 53181
Mr. William Nowack

M & W Industries
P. O. Box 952
Rural Hall, NC 27045
Mr. Jim Minor

Met-Pro Corporation
160 Cassell Road
Harleysville, PA l9438
Dr. Robert Kenson

Moco Fume Incinerators
First Oven Place
Romulus, MI 48174
Mr. Bill Diepenhorst

Nucon International, Inc
P.O. Box 29151
Columbus, OH 43229
Mr. Joseph Enneking

Ray-Solve, Inc.
100 West Main Street
Boundbrook, NJ 08805
Mr. Jules Varga

Reeco, Inc.
6416 Carmel Road
Charlotte, NC 28226
Mr. George Yundt

Salem Industries
245 South Mill Street
South Lyon, MI 48178
Mr. Lyman Thornton

Smith Engineering Company
P.O. Box 359
Broomhall, PA 19008-0359
Mr. Roy McIlwee

Stiles Machinery, Inc.
3965 44th Street Southeast
Grand Rapids, MI 49508
A. J. Stranges

Terr-Aqua Enviro Systems, Inc.
700 East Alosta, Unit 19
Glendora, CA 91740
Mr. Lynn Shugarman

Tigg Corporation
Box 11661
Pittsburgh, PA 15228
Mr. John Sherbondy

VARA International, Inc.
1201 19th Place
Vero Beach, FL 32960
Mr, Jerald Mestemaker

VIC
1620 Central Avenue, NE
Minneapolis, MN 55413
Mr. Tom Cannon

Weatherly, Inc.
1100 Spring St., NW, Suite 800 .
Atlanta, GA 30309
Mr. Rick Daeschner

ASSOCIATIONS

American Furniture Manufacturers
Association
P.O. Box HP-7
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